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INTERNATIONAL RAILWAY CONGRESS
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[686]

Competition by roads, waterways and airways.

V (1).

Continuing our investigation into competition with the railway, we publish below: two notes from the Reichsbahn (German State Railways); the regulations in force in Austria.

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GERMANY.

Note on the agreement recently entered into by the German State Railways (Reichsbahn) and motor road transport undertakings.

After long negociations, at the end of June, 1934, the Reichsbahn entered into an agreement with the principal road transport firms with the object of fixing the relations between German transport services. The result of this agreement will be that the former agreement dealing with railway consignments, between the Reichsbahn and haulage firms, will be replaced, without loss to the national economic system, by agreements between the Reichsbahn and road transport firms as a whole. In addition, competition by means of repeated rates reductions, which continued in spite of the law of the 6th October, 1931, and the defensive measures taken by the Reichsbahn against such competition, must in the future give way to collaboration between the Reichsbahn on the one hand and road motor transport undertakings and agencies on the other. This agreement has not, however, been passed as yet by the Minister of Transport of the Reich. In addition, its execution is subordinated to certain amendments of the law.

As an appendix, we give below a further note from the Reichsbahn, dealing with a road vehicle for carrying railway wagons used on the German railways. A technical description of this vehicle was published in the Bulletin *for February, 1934, p. 169.*

German road vehicle for carrying railway wagons.

(Paved railway siding.)

Road vehicles for carrying railway wagons are used for conveyance of wagon loads between the goods stations and the consignees' premises when there is no private siding.

Such vehicles make it possible for the

(1) Cf. *Bulletin of the International Railway Congress Association*, June to September 1934.

railways to give a door to door service in the case of the heaviest consignments, and save the consigner the cost of packing, the time and cost of loading and unloading, as well as avoiding damage due to atmospheric conditions and to transhipping, and losses through theft.

The Reichsbahn has perfected such vehicles upon entirely new lines, and the first of them were put into service in the Autumn of 1933. As the public has shown very great interest in this new method of transport, since then regular services with such vehicles have been organised in four different towns, to nine different consigness. In addition, many

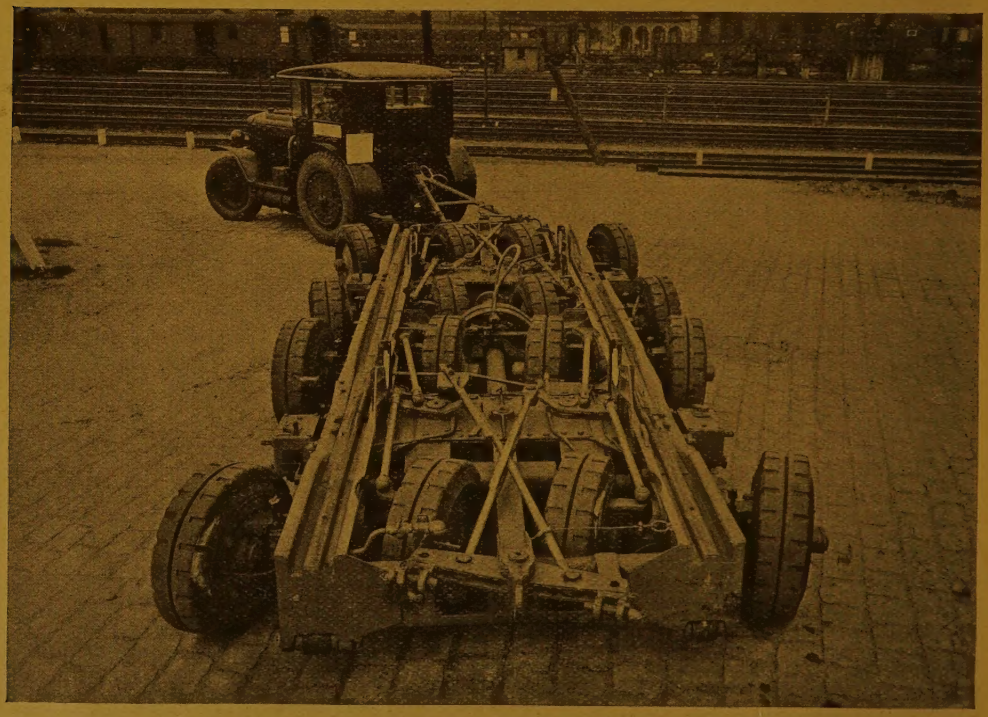


Fig. 1. — Unloaded road vehicle for carrying Reichsbahn wagons, with two coupled bogies, negotiating a 7-m. (23 ft.) curve.

occasional transports have been carried out with eight-wheeled wagons weighing up to 60 tons, in Berlin for example. Up to the present, about 2 500 wagons have been transported in this way. A certain number of new installations on similar lines are under consideration. The Reichsbahn actually owns 10 such vehicles which can be used not only for the transport of wagons but also for other heavy and bulky loads; other vehicles are under construction.

The good design of these vehicles, which run on 16 wheels carried on radial axles, prevents any possible damage to the goods, wagons and roads. Compared to other road vehicles, the new vehicles of the Reichsbahn are very smooth run-

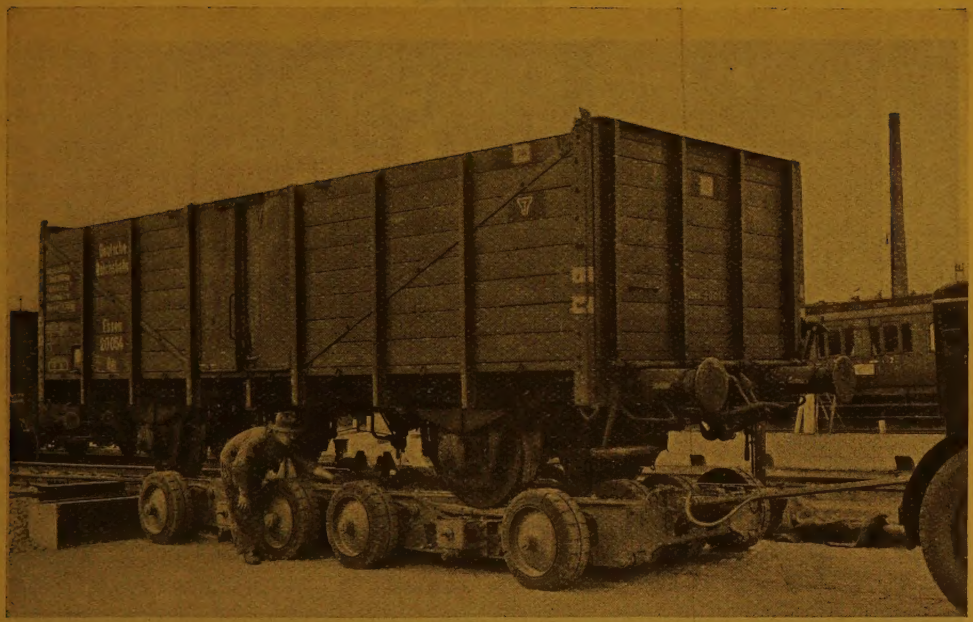


Fig. 2. — 20-ton wagon (Om type, 4.5-m. = 14-ft. 9 in. wheel base) being transferred from the transhipping platform onto the road vehicle.

Fig. 3. — The Reichsbahn's largest covered wagon (Glt type, 7-m. = 23-ft. wheel base) being loaded in a factory yard.

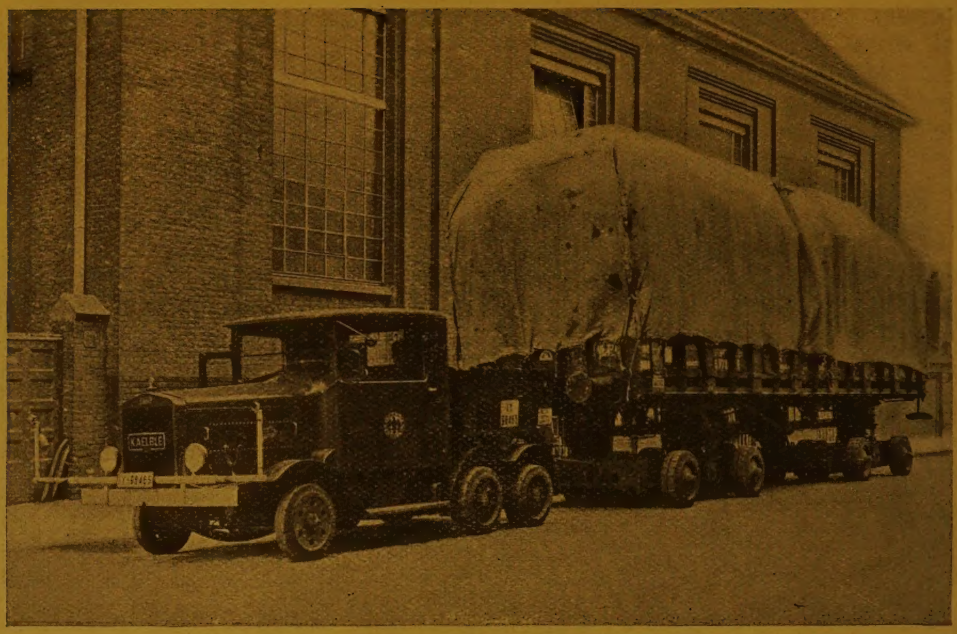


Fig. 4. — Transporting a stake-sided wagon (R type, 6-m. = 19 ft. 8 in. wheel base)

ning, and for this reasons have rapidly and easily taken their place among road traffic vehicles.

AUSTRIA.

The information given below has been supplied by the General Management of the *Austrian Federal Railways*.

It has been classified under three headings : legislative decisions, measures taken by the railways, and collaboration between the railway and the road motor.

I. — Legislation on road motor traffic.

The law on road motor traffic and the decree for carrying it out, which are of particular importance from the point of view of technical operation, came into force on the 1st June, 1930. As far as the relations between railway and road are concerned, mention must be made of two measures imposed by this law, i. e. obligatory insurance against accident, which applies to all motor vehicles, and the interdiction, in principle, to carry more than 8 persons per motor lorry. This interdiction has been made still more rigorous by the decree on motor lorry traffic which will be dealt with later on.

A ministerial decree of the 4th February, 1931, laid down the obligation to submit for approval, and to publish, the timetables and rates of periodical passenger transport services by motor vehicles, and a ministerial decree of the 31st March, 1931, made it necessary for road hauliers carrying goods by motor vehicles with a tare weight of more than 350 kgr. (770 lb.) to obtain a licence. Up to that time they had been free.

On the 1st May, 1931, a tax was levied on petrol, at first at the rate of 13 groschen per kilogramme but increased after the 1st October, 1931, to 30 groschen.

Also from the 1st May, 1931, another tax was added to the petrol tax in the case of motor vehicles used for passenger services, based on a scale of from 16 to 600 schellings a year according to engine power. Motor taxis und other motor vehicles plying for hire are exempt from this tax.

In addition, from the 1st November, 1931, to the transport tax on passengers and goods by motor vehicles was added a duty on the cost of transport, usually 3 %, and in the case of public services exempt from the goods transmission tax (2 %), this duty amounts to 5 %. Transport of passengers and goods within the boundaries of a single parish is exempt from this tax.

On the 1st January, 1932, a law came into force which subjects passenger and goods transport services carried out by public motor vehicles, periodically against payment beyond the limits of a town between given points, to a special concession, the granting of which no longer depends upon industrial, but on traffic considerations. Such a concession can only be granted if the undertaking is not against the public interest. It is refused if the new service encroaches wholly or in part on the sphere of action of the railways or waterways, and would therefore compete with the latter harmfully from the economic point of view.

Before a concession is granted the railway must give its opinion, otherwise the concession may be cancelled. The railway has the right to ask for the concession on its own behalf if the proposed motor service encroaches on its sphere of action. It also has the right to appeal, within the prescribed time, against decisions taken contrary to the opinion it expressed. The holding of a concession obliges the holder to operate the motor service continuously, to apply the same rates and conditions to all users, such rates and conditions having been approved by the competent authorities, and published; he is also obliged to carry all passengers and goods meeting the above conditions, for which his regular services are sufficient. The organisations dealing with periodical group excursions as well as, in the case of goods services, consignments carried at regular intervals to order, are not required to obtain a special concession.

On the 1st July, 1933, the « Lastkraftwagenverkehrsordnung » (Ordinance relating to motor lorry traffic) came into force. Its object is the fundamental regulation of goods transport by motor lorry. This law affects commercial transport as well as industrial traffic and applies to all transport of goods by motor lorry carried out either regularly or occasionally.

According to the terms of this ordinance, the transport of goods against payment by motor lorry can only take place if fixed minimum rates are applied. These rates have been calculated on the basis of the cost of motor transport and are arranged so that short-distance traffic will ordinarily go by road and long-distance traffic by rail. According to the nature of the goods, the limit lies between 50 and 100 km. (31 and 62 miles).

In the case of industrial transport, the law lays down that goods cannot be transported more than 100 km. (62 miles) except in certain special cases. In addition no person not employed by the undertaking in question may be carried by road.

On the 1st February, 1934, by virtue of the law on motor lorries, the Federal Minister of Transport and Commerce set up a control over motor lorry traffic. At the present time, in the whole country, there are 16 controllers charged with seeing that in their district the motor lorry traffic complies with the regulations. They are authorised to carry out inquiries among hauliers and consignors. The controllers are in constant contact with the competetent authorities to whom they report any infringement of the law. The authorities are required to publish in the newspapers, in an appropriate form, judgments passed upon offenders if the penalties inflicted upon them are likely to serve as a salutary warning.

The law on motor lorries was in force until the 30th June, 1934, but this limit is likely to be extended.

A new regulation of passenger motor transport services as a whole, which will also take into account occasional transport in particular, is under investigation at the present time.

II. — **Measures taken by the railways against motor competition.**

a) *Passenger traffic.* — The Austrian Federal Railways are constantly endeavouring to improve their services. The steam trains have been speeded up in many cases and their frequency increased.

During the previous year, the rail motor coach services have been extended to the main lines and have been increased. Thirty new rail motor coaches have been added to the former stock of 17. These rail motor coaches are to be recommended in the struggle against motor competition because of the operating economies they make possible in comparison with steam traction.

In addition, new stops have been introduced on lines where there is little traffic, which are now worked by rail motor coaches.

On all those lines where, thanks to the steps taken, improved transport facilities have been offered to the public, the railway traffic has increased.

Among measures of a rating nature, special mention must be made of return tickets at very reduced rates, issued on Sundays and holidays, which were introduced in 1931 and generally adopted in 1932. This measure has not only stopped the progressive decrease in Sunday and holiday excursion traffic due to the economic crisis, but has in many cases restored such traffic. In the period from the 15th March to the 30th June, 1934, excursion tickets, known as Spring tickets were introduced, valid for places on the outskirts of the large towns for maximum distances of 40 km. (25 miles) and on working days between 2.0 p. m. and midnight; the outward and return journey must be made the same day. The result of this innovation still remains to be seen. In order to bring back a larger part of the public to the railway, in 1932, for the first time, excursion trains to a given place or to an unknown place at special fares were introduced; up to the present time these trains have proved very popular, and as they nearly always run full, they are profitable in spite of the low rate charged.

Another means of re-awakening public interest in the railway is the lottery, organised for the first time in the 1933 Spring and held again this year, the prizes being free tickets of different classes to different places, sometimes including a free stay at a hotel. Such lotteries have proved popular.

b) *Goods traffic.* — From the point of

view of commercial and technical operation, rapid transport of parcels traffic, i. e. of goods most likely to be diverted to motor transport, is assured by the introduction of light goods trains (« Leig ») and by attaching wagons loaded with such goods to the mail trains and night parcels trains, and sometimes also to passenger trains. Special care has been taken to avoid all loss of time at transhipment stations. In order to accelerate tranship operations, and the parcels traffic in general, certain transhipment stations have been suppressed or amalgamated.

The waybill introduced in 1932 in internal service and issued in duplicate simplifies operations, and consequently makes rapid despatch of consignments possible.

From the rating point of view, the following measures must be mentioned : linking up of certain rates for raw materials and semi-manufactured goods with the despatch by rail of the finished articles; application of very reduced rates to goods grouped together by agent-consignors between important traffic centres; special reduced rates for goods of all kinds carried up to 110 km. (68.3 miles) when sent in given minimum quantities.

It is now proposed to link up the reduced rates for used empty packings with definite proof that the goods were carried by rail. In this way it is hoped to do away with the abuse consisting in sending goods by motor lorry and the empty cases back by railway. After the law on motor lorries of July, 1933, came into force (Cf. Chapter I), it was found possible to revise the reduced rates called for by motor competition on the basis of the legal minimum rates for transport by road, and to abolish a large number of them completely.

III. — Collaboration between the railway and the motor services.

In the case of passenger traffic, on routes where motor competition is particularly severe, especially around large towns, agreements have been made with motor bus services. The essential clauses of such agreements are that the timetables of the bus services and the fares charged are to be drawn up so as to fit in with the railway timetables and rates, and the total receipts from the common journey are to be divided between the railway and bus service according to a given ratio. This ratio depends on the receipts collected before the agreement was made. The operators of bus services agree to pay the railway certain minimum sums which vary with the intensity of the traffic on the different lines. The agreements in question have given good results. Competition has disappeared and so it has been possible to abolish various measures taken to combat it. Consequently both the railway and motor undertakings intend to make similar agreements in the case of other services.

The bus services introduced by the railway in 1928 for the protection of its interests were considerably extended in 1929 and 1930, as well as in 1931, by the purchase of an important private motor transport undertaking, and have fulfilled the object for which they were set up. In 1933 the system of bus services operated by the Austrian Federal Railways covered about 2 700 km. (1 680 miles).

In the case of goods traffic, at the present time there are no special agreements with private undertakings in order to co-ordinate railway and motor services. It is hoped that the law on motor lorries mentioned above (chapter I) will lead to a natural division of short-distance and long-distance traffic between the road and the railway.

[621. 43]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION.

INQUIRY INTO QUESTIONS OF IMMEDIATE INTEREST.

(*Decision taken by the Permanent Commission at its Meeting held on July 29th, 1933.*)

QUESTION I.

Rail motor cars from the point of view of their construction.

A. — Types of engines. — Forms of transmissions. Running gear. — Brakes.

REPORT

(*Countries of the European Continent*),

by L. DUMAS,

Ingénieur en chef adjoint du Matériel et de la Traction, French Nord Railway,

and JEAN LÉVY,

Chef adjoint du service du Matériel et de la Traction, French State Railways.

FOREWORD.

On account of its length, the subject has been divided up into two parts :

1. Engine, running and brake gear;
2. Body and various fittings.

The present report deals with the first part only. It includes :

first of all, a description, part by part, of the apparently best designs;

then a summary of the original features of the principal rail motor coaches in existence, classified by the country of origin.

It was found quite impossible to describe all the rail motor coaches now in service; there is, in fact, a very great number of types, some of them already old, with features that have since been discontinued. This report is limited to those a very large number of which are in service at the present time, or those with original features likely to be retained in new constructions.

The report deals with petrol rail motor coaches, as well as those with Diesel engines; but as the petrol engine has been adapted to rail motor coach use without modification, no detailed description of it will be given. It should be pointed out, however, that if the present tendency is to develop the Diesel engine with its lower fuel consumption, its greater power per engine, and its reduced fire risk, certain designers or users remain faithful to the explosion motor as being lighter and absolutely reliable in service.

As this report covers the Continent of Europe only, the Reporters deemed it unnecessary to deal in detail with the question of steam railcars, which are very interesting from several aspects, but of which only a comparatively limited

number exist on that Continent; they are, however, mentioned in the last chapter. Thus, no description is given of the Sentinel railcars, a certain number of which are in service in England and a few on the Continent (Rumania and Belgium). The same remark applies to the Birmingham railcars (Egypt and Belgium) and the Doble railcars (England and Germany).

It seemed well to start this report on the design and construction of rail motor coaches with a short chapter on the test methods and the measuring devices by which it is now possible to compare, from the practical point of view, the different types of rail motor coaches actually in service, and to measure the stresses these vehicles set up in the track, and between their different component parts.

By such tests and measurements alone it will be possible, on the one hand, to make a wise choice from among the different prototypes, and on the other, to improve the behaviour of vehicles on the track, and eventually to increase their speed.

If, as the Reporters earnestly hope, the application of these tests and measurements quickly became general, the field of possible comparisons would be considerably extended, and the development of the rail motor coach would be greatly speeded up.

The plan of the present report is as follows :

Chapter I. — Test methods and measuring instruments.

Chapter II. — Diesel traction engines for rail motor coaches.

Chapter III. — Distant control on rail motor coaches with mechanical drive.

Chapter IV. — Electric transmissions.

Chapter V. — Hydraulic transmissions.

Chapter VI. — Running gear and bogies.

Chapter VII. — Brakes.

Chapter VIII. — Rail motor coaches in the various countries.

* * *

CHAPTER I.

Test methods and measuring instruments.

I. — *Rail motor coach constants and their determination.*

These constants are ascertained in France by the method developed by Messrs. Ferrand and Rousselet of the State Railways. By using this method, the following characteristics can be ascertained for each type of rail motor coach :

1. the rolling resistance constant F_0;

2. the aerodynamical resistance constant KS.

These two constants are those used in the speed resistance curves :

$$F = F_0 + KSV^2;$$

3. the efficiency of the transmission;

4. the efficiency of the gear box at a particular gear ratio;

5. the gradient climbing capability;

6. a new constant called « nervosité relative » or « relative accelerative aptitude ».

1. *Rolling resistance constant* F_0.

This constant is found by allowing the coach to coast at low speed, with the engine cut out, down a known gradient of, for example, 5 mm. per metre (1 in 200), and noting the times taken to cover each 100 metres to rest. The deceleration is then calculated, and from it F_0.

2. *Aerodynamic constant KS.*

This constant is obtained from the maximum coasting speed of the vehicle as follows. The vehicle is allowed to run down different gradients with the engine cut out, the gradients being about 1 in 40 for vehicles on pneumatic tyres, and 1 in 100 for steel-tyred coaches.

The limiting speed is obtained by successive approximations from the speeds recorded.

When these two constants, F_0 and KS, are known, the following curves can be accurately drawn :

a) The decelerating force, or resistance-speed curve, in terms of the speed, on the level and on the various rising and falling gradients;

b) The resistance-speed curve, this being obtained from curve (*a*) by multiplying the ordinates by the speed.

3. *Efficiency of the transmission.*

When the maximum speed of the vehicle on the level has been found, the power required at the tread to maintain this speed is read off the curve. The ratio of this power to that developed by the engine at the speed considered gives the efficiency of the drive.

When the motor coach is fitted with reversing gear with spur gears, the efficiency of the transmission can vary considerably according to the direction of running. A double series of trials should be carried out in such cases.

4. *Efficiency of the gear box.*

The efficiency taken is that of the last but one speed, that is to say it is the ratio of the powers at the tread in the last but one speed and in the last speed, the speed of the engine being constant. This efficiency is found in the same way as that of the transmission, but by measuring the maximum speed obtained in the last but one gear on a sufficiently steep gradient (about 1 in 50 in practice).

In the case of gear boxes with a multiplying gear, the efficiency of the direct drive is measured and those of the indirect drives above and below it.

If these two last efficiencies are to have any meaning, the engine must be in as good order as on the test bench.

5. *Gradient climbing capability.*

The climbing ability curve represents the speeds that can be reached on the different rising gradients. For each gradient, the curve giving the power at the tread on direct drive and intermediate gears can be drawn, as the curve of the engine power in terms of the speed of the coach and also the efficiency of the drive and gear box are known.

For each gradient, the resistance in terms of the speed is also known. The intersection of these two curves gives the maximum speed on the gradient considered.

The curve of gradient climbing capability represents, within the limits of the scale, the theoretical acceleration the vehicle is capable of on the level, at the speed V, with the engine developing its maximum power at that speed.

6. *Acceleration aptitude constant.*

If the engine were to reaccelerate the vehicle under ideal conditions, the starting curve would effectively coincide with the theoretical acceleration curve, that is to say the curve representing its gradient climbing capability, and everything would go on as if the engine were working under a constant regimen when the curve was drawn. In practice, however, some time is lost by the engine in starting up and in running up to maximum power.

The accelerative capability of the motor coach can be represented by the ratio between the ordinates of the curve of actual starts and those of the theoretical curve (corresponding to the curve of gradient climbing capability). The starting curves are, of course, the usual speed-time curves.

It is indispensable that the whole of the above trials be carried out on carefully selected gradients, accurately checked by the permanent way department. Care must be taken to avoid conditions likely to upset the results, such

as wind, greasy rails, newly laid track, or track under repair, etc... One has to be sure too that the engine is developing its full power as on the trial bench when its power curves were taken, and nothing more.

II. — *The starting curve of a rail motor coach and its accurate determination.*

An accurate starting curve, giving the speeds at second intervals, can be obtained with an appropriated instrument, such as that made by the T. E. L. Company.

This instrument actually records, second by second, the average speed on a paper roll which moves 2 millimetres per metre travelled. The speed-time curve therefore is easy to draw. These curves are very instructive, as they show quite clearly that at each gear change in the case of a rail motor coach with mechanical drive, the speed drops slightly; the better the design of the gear, the less the drop.

The drive is transmitted to the instrument by a flexible cable with a standard connection.

The paper can be started or stopped at any time by means of a small lever in front of the instrument.

The difference between the speed over two successive intervals gives the speed increase (*dv*). If this change is directly measured and multiplied by a constant for the particular instrument, the absolute value of the acceleration is obtained. Accelerations of the order of 0.05 m. (2 inches) per second per second are readily measured.

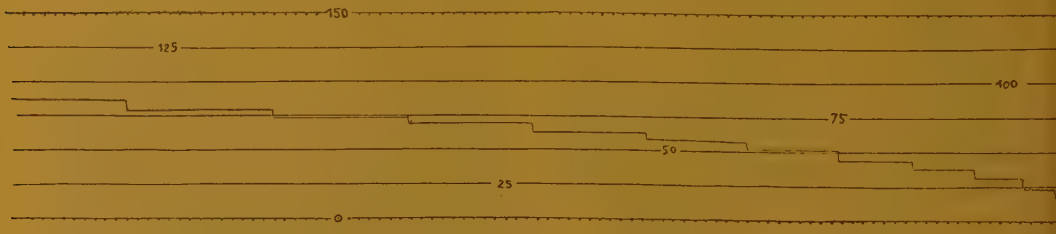


Fig. 1. — Stopping curve of railcar, recorded by the T.E.L. apparatus.

The same instrument allows of the stopping curves of railcars being taken quite accurately; figure 1 shows such a curve (scale about 1/2).

III. — *Practical determination of the reactions felt at any point in the body of rail motor coaches.*

These reactions are important, affecting as they do the passengers' comfort.

They can be measured with great accuracy by accelerometers such as the H.M.P. (Hubert, Magnan, Plagnol). This instrument can be set to operate longitudinally, transversely, or vertically, which gives the three components of the reactions.

The acceleration is measured by recording on a paper band, travelling proportionately to the time, the pressure exerted on a mixture of water and glycerine by a mass of mercury free to move in a direction parallel to that of the accelerations being measured.

This instrument is shown in diagram form in figure 2. It consists of a cylindrical tube in which the mercury is held between the two membranes *a* and *b*. One of them, *b*, forms the face of a box filled with compressed air by which the instrument is calibrated. The other, *a*,

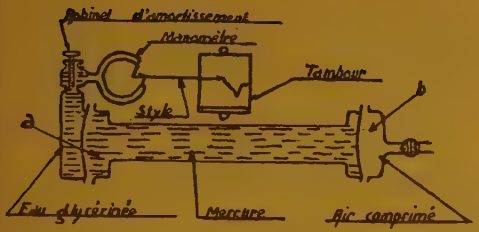


Fig 2. — H.M.P. accelerometer.
Weight : 15 kgr. (33 lb.).

Explanation of French terms:

Robinet d'amortissement = Damping out valve. — Manomètre = Gauge. — Tambour = Drum. — Stylo = Recording pen. — Eau glycérinée = Mixture of water and glycerine. — Mercure = Mercury. — Air comprimé = Compressed air.

transmits the pressure to a gauge having the lowest possible period of oscillation, through a mixture of water and glycerine. A needle valve is fitted in the glycerine-water pipe to control the movement of the gauge needle. The neutral or zero line of the scale can be set as desired by suitably regulating the air pressure in the air box. Both the gauge branch pipes are connected to a recording pen.

IV. — *Practical determination of the forces acting between the wheels and rails.*

These forces can be measured by the two instruments described below. These instruments were designed and perfected by Mr. MAUZIN, of the Paris-Orleans Railway.

1. — Mauzin wheel gauge recorder (fig. 3).

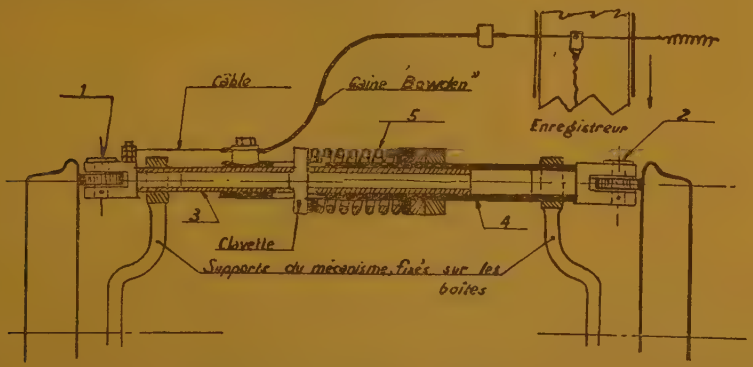


Fig. 3. — Diagram of the Mauzin apparatus recording the distance between wheels.

Explanation of French terms:

Câble = Cable. — Gaine Bowden = Bowden sheathing. — Enregistreur = Recorder. — Clavette = Pin. — Supports du mécanisme... = Bearers of the mechanism, fastened to the axle boxes.

This instrument consists essentially of two ball bearings (1 and 2) fastened to the ends of two telescopic tubes (3 and 4). A spring (5) keeps them away from each other and holds the ball bearings against the inside faces of the tyres of a pair of wheels at the top.

The differences of length given by the two tubes is transmitted by a Bowden cable to a recorder.

The instrument is calibrated by exerting a known force on the tyres, and shows the comparative magnitude of the dynamic forces to which the wheels are subjected.

2. Mauzin quartz piezo-electric instrument (fig. 4).

This instrument is based on the following principle :

When a plate of quartz is compressed,

electricity of contrary sign is produced on its two faces. The charge on the faces of the quartz is transformed into current by an electrometric lamp. The current from this lamp is amplified by resistance amplification (wireless type) and is then fed to an oscillograph, the amplitude of which gives the variations of the charge on the quartz plate and, therefore, of the variations of the force acting.

This instrument is extremely accurate,

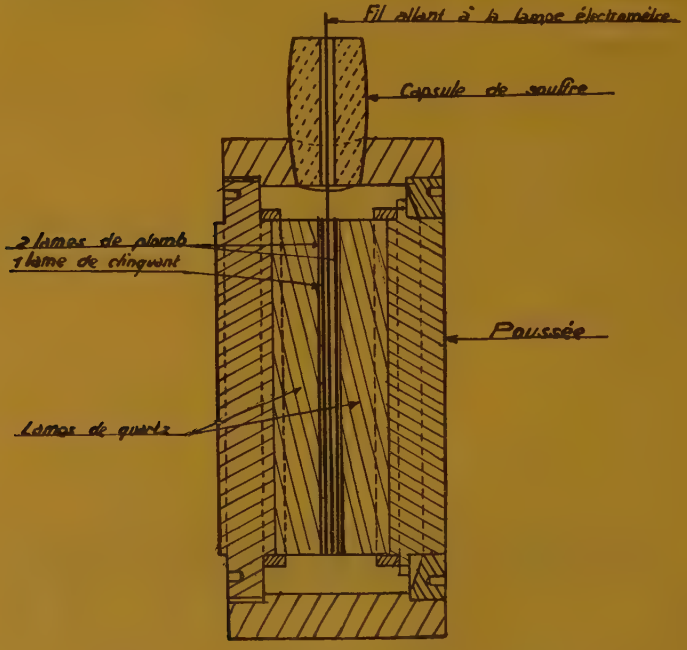


Fig. 4. — 2 quartz plates arranged in parallel.

Explanation of French terms:

Fil allant... = Wire to electrometer lamps. — Capsule de soufre = Sulphur cup. — 2 lames de plomb = 2 lead sheets. — 1 lame de clinquant = 1 foil sheet. — Poussée = Thrust. — Lames de quartz = Quartz plates.

as the inertia of the quartz may be overlooked.

The instrument is very easily calibrated, a hydraulic jack and pressure gauge being used for this purpose.

The pressure exerted on the quartz should be perfectly along the normal thereto, and the wiring from the quartz to the first valve has to be extremely well insulated (beads of pure sulphur are used to insulate the wire, the whole being carried in a tube filled with dry air).

CHAPTER II.

Diesel traction engines for rail motor coaches.

Rail motor coach builders wishing some years ago to use heavy oil engines working on the Diesel cycle found themselves up against a serious difficulty : where to find an engine really adaptable to the vehicle they had in mind.

The railcar Diesel engine of over 100 H.P. had to be designed, built, and

perfected in all its details. Engines picking up well, and running at high enough speeds to give the power-weight ratio required on vehicles essentially of light weight, have only been available recently.

The attached tables I and II summarise the leading characteristics of rail motor coach Diesel engines used on the railways who replied to the questionnaire sent out by the International Railway Congress Association.

In dealing with the different details of the Diesel engines we presume that the general characteristics of these engines are known, and we shall therefore only call attention to the most interesting points of design so as not to be too long winded.

The three essential qualities of a rail motor coach engine, it should be remembered, are : power, endurance, lightness.

Power.

The size, comfort, ans speed of rail motor coaches have constantly grown from their earliest days, to meet service requirements. The original four-wheeled vehicles weighed some ten tons and carried about forty passengers at 60 km. (37.3 miles) an hour. Many of these vehicles still exist in Central Europe with 80 to 100-H. P. engines. Today there are rakes, still called rail motor coaches, of three units (usually 1 trailer between 2 driving), built or under construction, examples being the Dutch trains (in service), French Nord articulated trains (in service), and the trains for Denmark (under construction). These sets weigh about 100 tons, with a total horse power of 800 given by two or four Diesel engines.

The characteristics of the rail motor coach are governed by the kind of line to be operated. In all cases, considerable power, in fact an excess of power, is necessary.

With this amount of power, the stock can be run at high speed over the main lines without working the engine to its limit. On secondary lines with frequent stops, the vehicle can be accelerated rapidly, as if not, a high overall speed is impossible.

Table I shows that there are a number of rail motor coach engines of 400-H. P. The Reichsbahn is experimenting at the present time with a 600-H. P. supercharged Maybach engine for one of its fast rail motor coaches.

Endurance.

The rail motor coach must have a good endurance and be free from liability to fail in service. For this reason the engine should be nursed by not being run at full power all the time.

The Diesel engine is still a novelty on the railways and the driving and maintenance staff are still not fully experienced with it. With the few units in service, spare vehicles are not always available at the key points from which the lines worked by rail motor coaches radiate. An engine which will run long mileages without trouble is therefore essential from an operating point of view. The desired mileage can be fixed at 75 000 km. (46 600 miles) at the present time.

The engines should not be difficult to repair so that they are out of service as short a time as possible. The parts of engines of the same type should be strictly interchangeable.

Mechanical transmission, now much used in some countries, means an engine with particular qualities.

Whereas the stationary type of engine runs at constant speed with little load variation and the traction engine with electric drive works under certain well defined conditions, the railcar engine, especially with mechanical drive, has, on the contrary, to be able to develop its full torque under all conditions, over a very wide range of speeds.

This involves good combustion and minimum vibration.

TABLE I. — Characteristics of the engi

Number.	ENGINE.	Licensee if any.	Horse-power nominal.	Horse-power maximum.	R. p. m., nominal.	Weigh of engi Kgr.	
1	KRUPP, F. A. type	Delaunay-Belleville	65	78	1000	770	
2	C. L. M. 85 L. C. 3, 2-stroke	Junker licence. Built in France.	80	88	1500	570	
3	RENAULT, 6 cylinders	Built in France.	85	93.5	1500	1000	
4	GANZ.	Built in Hungary.	95	110	1650	770	
5	RENAULT, 6 cylinders	Built in France.	100	120	1500	1000	
6	C. L. M. 85 L. C. 4, 2-stroke	Junker licence. Built in France.	100	119	1500	800	
7	GANZ	Built in Hungary.	110	130	1000	1920	
8	M. A. N.	Built in Germany.	120	150	1400	1025	
9	LORRAINE.	Built in France.	120	152	1500	818	
10	GANZ.	Built in Hungary.	125	150	1000	2000	
11	BERLIET	Built in France.	125	150	1500	1130	
12	M. W. M.	Built in Germany.	125	150	1000	1800	
13	GANZ.	Built in Hungary.	130	150	1350	1050	
14	MERCEDES-BENZ	Built in Germany. Licensee for France : C.O.D.R.A.	135	150	1700	1000	
15	SAURER B X D, 4-stroke	Switzerland. Built in France.	140	154	1500	1160	
16	M. A. N.	Built in Germany.	150	160	1500	1340	
17	BRNO-KRALOVO-POLSKA	Built in Czechoslovakia.	160	175	1300	2000	
18	M. W. M.	Built in Germany.	170	225	800	2690	
19	M. A. N.	Built in Germany. Builder in France : ACENOR.	170	180	900	2200	
20	MAYBACH	Built in Germany.	175	180	1400	1100	
21	M. A. N.	Built in Germany.	190	225	1000	2060	
22	M. A. N.	Built in Germany.	210	225	1400	1490	
23	MAYBACH	Built in Germany.	210	220	1400	1650	
24	RENAULT, V-type	Built in France.	220	240	1500	1560	
25	FRICHS	Built in Denmark. Builder in France : CORPET.	220	240	1000	...	
26	GANZ.	Built in Hungary.	220	310	1200	1850	
27	MERCEDES-BENZ	Built in Germany.	300	330	1500	1800	
28	CESKOMORASKA-KOLBEN-DANĚK .	Built in Czechoslovakia.	350	380	900	4360	
29	MAYBACH	Built in Germany.	380	410	1300	2030	
30	M. A. N.	Built in Germany.	420	450	1400	3150	

M. A. N. = Maschinenfabrik-Augsburg-Nürnberg. — M. W. M. = Motoren Werke-Mannheim.

eight ower atio Lb. H.P.	Number of cylinders.	Bore		Stroke		Mean piston speed $V = \frac{C^m Nr/m}{30}$		Mean pressure 4-stroke cycle $382 \frac{1}{D^2 C m n V m/s}$		Fuel oil consumption per H.P.-hour				Lubricating oil consumption per H.P.-hour	
										Full load		Half load			
		Milli-metres.	*Inches.*	Milli-metres.	*Inches.*	m./sec.	*ft./sec.*	kgr./cm²	*lb./sq. inch*	Grammes.	*Lb.*	Grammes.	*Lb.*	Grammes.	*Ounces.*
26.0	4	135	*5.31*	200	*7.87*	6.65	*21.81*	5.1	*72.53*	195	*0 430*	...	...	4	*0.141*
14.3	3	85	*3.35*	240	*9.45*	6.0	*19 68*	5 85	*83.20*	205	*0.452*	270	*0.617*	5-6	*0.176-0.212*
25.7	6	115	*4.53*	170	*6.69*	8.50	*27.88*	4.8	*68 27*	210	*0.463*	250	*0.551*	5	*0.176*
17.8	8	105	*4 13*	140	*5.51*	7.68	*25.20*	5 35	*76.09*	200	*0.441*	224	*0.494*	3	*0.106*
22.0	6	125	*4.92*	170	*6.69*	8.50	*27.88*	4.8	*68.27*	210	*0 463*	250	*0 551*	3	*0.106*
14.9	4	85	*3.35*	240	*9.45*	6.0	*19 68*	5.5	*78 23*	214	*0.472*	280	*0.617*	4	*0.141*
38.6	6	150	*5.91*	185	*7.28*	6.15	*20.17*	5.05	*71.83*	195	*0.430*	220	*0.485*	3	*0.106*
...	6	140	*5.51*	180	*7.09*	8.40	*27.56*	4.6	*65.43*	182	*0.401*	217	*0.478*	8	*0.282*
15.0	6	126	*4.96*	180	*7.09*	9.0	*29.53*	5 5	*78.23*	200	*0.441*	230	*0.507*	6	*0.212*
35.3	6	160	*6.30*	185	*7.28*	6.15	*20.18*	5.05	*71.83*	195	*0.430*	220	*0.485*	3	*0.106*
20.7	6	135	*5 31*	180	*7 09*	6.59	*21 62*	4 7	*66 85*	202	*0.445*	241	*0.478*	2	*0.071*
31.7	6	150	*5.91*	200	*7 87*	6 65	*21.81*	4.7	*66 85*	190	*0.419*	225	*0.496*	...	...
17.8	6	135	*5 31*	185	*7.28*	8.30	*27.23*	5 45	*77 51*	200	*0.441*	224	*0.474*	3	*0.106*
16.3	6	125	*4.92*	170	*6.69*	9.70	*31.82*	5.70	*81.07*	195-220	*0.430-0.485*	260	*0.573*	5-8	*0.176-0.282*
18.3	6	130	*5.12*	180	*7 09*	9.0	*29.53*	5.9	*83.91*	207	*0.456*	...	...	4-8	*0.141-0.282*
19.6	6	150	*5.91*	180	*7.09*	9.0	*29.53*	4.75	*67.56*	200	*0.441*	...	...	5	*0 176*
27 5	8	140	*5.51*	180	*7.09*	7.8	*25.59*	5.0	*71.11*	190	*0.419*	230	*0 507*	5	*0.176*
34.6	6	175	*6.89*	240	*9.45*	6.40	*21 0*	5.5	*78.23*	190	*0.419*	230	*0.507*	...	...
28.7	6	175	*6.89*	220	*8.67*	6.6	*21.65*	5.35	*76.09*	200	*0.441*	196	*0.432*	5	*0.176*
13.9	6	140	*5.51*	180	*7.09*	8.4	*27.56*	6.75	*96.00*	213	*0.469*	249	*0.549*	5	*0.176*
23.8	6	175	*6.89*	220	*8.67*	7.30	*23.95*	5.40	*76.80*	185	*0.408*	...	...	5	*0.176*
15.6	6	175	*6.89*	180	*7.09*	8.0	*26.25*	5.5	*78.22*	185	*0.408*	...	...	5	*0.176*
17.4	6	150	*5.91*	200	*7.87*	9.30	*30.51*	6.30	*89.60*	210	*0.463*	210	*0.463*	5	*0.176*
15.6	12	130	*5.12*	170	*6.69*	8.5	*27 89*	4.9	*69 69*	205	*0.452*	245	*0.540*	5	*0.176*
...	6	175	*6.89*	260	*10.24*	8.6	*28.21*	5.35	*76.09*	175	*0.386*	185	*0.408*	...	...
18.5	6	170	*6.69*	220	*8.67*	8.8	*28.87*	5.5	*78.23*	185	*0.408*	208	*0.459*	3	*0 106*
13.2	12	138	*5.43*	170	*6 69*	8.4	*27.56*	5.65	*80.36*	200	*0.441*	220	*0 485*	8	*0.282*
27.5	6	220	*8 67*	280	*11 02*	8 4	*27.56*	5.47	*77.80*	175	*0.386*	200	*0.441*	5	*0.176*
10.8(1)	12	150	*5 91*	180	*7.09*	8 4	*27.56*	6.80	*96.72*	...	...	...	...	...	...
16.5	12	175	*6.89*	180	*7.09*	8.4	*27.56*	5.20	*73.96*	185 ± 10%	*0.408* ± 10%	...	...	5	*0.176*

(1) Weight of engine without clutch, flywheel nor starter.

Number.	ENGINE.	Nominal horse power.	Injection.			Bearings.		Connecting rod big end bearings.
			Pumps.	Injectors.	Method of injection.	Number.	Nature.	
1	KRUPP, F. A. type	65	Krupp.	Krupp.	Direct.	5	Brass. — Antifriction-lined. Hoyt metal.	Brass. — Antifriction-lined. II D.
2	C. L. M. 85 L. C. 3, 2-stroke	80	C. L. M.	C. L. M.	Direct.	4	Brass. — Antifriction lined.	
3	RENAULT, 6 cylinders	85	Bosch-Lav.	Bosch-Lav.	Direct.	7	Steel. — Antifriction.	
4	GANZ	95	Ganz.	Ganz.	Precombustion chamber.	9	Brass. — Antifriction. Glyco alloy or Hoyt 10.	
5	RENAULT, 6 cylinders	100	Bosch-Lav.	Bosch-Lav.	Direct.	7	Steel. — Antifriction.	
6	C. L. M. 85 L. C. 4, 2-stroke	100	C. L. M.	C. L. M.	Direct.	5	Brass. — Antifriction.	
7	GANZ	110	Ganz.	Ganz.	Precombustion chamber.	4	Brass. — Antifriction. Glyco alloy or Hoyt 10.	
8	M. A. N.	120	Bosch.	Bosch.	Direct.	7	Brass. — Antifriction.	
9	LORRAINE	120	Bosch.	Bosch.	Precombustion chamber.	7	Steel. — Antifriction.	
10	GANZ	125	Ganz.	Ganz.	Do.	4	Brass. — Antifriction. Glyco alloy or Hoyt 10.	
11	BERLIET	125	Bosch.	Bosch.	Injection air chamber in piston.	7	Brass. — Antifriction.	Steel. — Antifriction.
12	M. W. M.	125	M. W. M.	M. W. M.	Direct.	7	Brass. — Antifriction.	
13	GANZ	130	Ganz.	Ganz.	Do.	7	Brass. — Antifriction. Glyco alloy or Hoyt 10.	
14	MERCEDES-BENZ	135	Bosch.	Bosch.	Do.	7	Brass. — Antifriction.	
15	SAURER B X D, 4-stroke	140	Bosch-Lav.	Bosch-Lav.	Injection air receiver.	7	Roller.	Brass. — Antifriction.
16	M. A. N.	150	Bosch.	Bosch.	Direct.	7	Brass. — Antifriction.	
17	BRNO-KRALOVO-POLSKA	160	Bosch.	Bosch.	Do.	5	Antifriction.	
18	M. W. M.	170	M. W. M.	M. W. M.	Precombustion chamber.	7	Brass. — Antifriction.	
19	M. A. N.	170	Bosch.	Bosch.	Direct.	7	Brass. — White metal.	
20	MAYBACH	175	Maybach.	Maybach.	Do.	7	Roller.	
21	M. A. N.	190	Bosch.	Bosch.	Do.	7	Brass. — Antifriction.	
22	M. A. N.	210	M. A. N.	Bosch.	Do.	7	Do.	
23	MAYBACH	210	...	...	...	7	Roller.	
24	RENAULT, V-type	220	Précision Mécanique.	Précision Mécanique.	Direct.	7	Steel. — Antifriction. White metal at present.	
25	FRICHS	220	Bosch.	Bosch.	Do.		...	
26	GANZ	220	Ganz.	Ganz.	Precombustion chamber.	7	Brass. — Antifriction. Glyco alloy or Hoyt 10.	
27	MERCEDES-BENZ	300	Bosch.	Bosch.	Do.	7	Brass. — Antifriction.	
28	CESKOMORAVSKA-KOLBEN-DANĚK	350	Bosch.	Bosch.	Direct.	7	Antifriction.	Antifriction.
29	MAYBACH	380	Deckel.	Deckel.	Do.	7	Roller.	...
30	M. A. N.	420	M. A. N.	Bosch.	Do.	14	Brass. — Antifriction.	

Note. — M. A. N. = Maschinenfabrik-Augsburg-Nürnberg. — M. W. M. = Motoren Werke-Mannheim.

ines in use on the various Railways.

Kind of metal.				Lubrication.	Starting.	Control.
Connecting rods.	Crankshaft.	Casing.	Cylinders.			
Duralumin. (Navy.)	Nick.-chr. steel.	Silumin (light alloy).	Cast iron L.	Pressure.	Electric.	Mechanical.
Nick.-chr. steel.	Do.	Aluminium.	Do.	Do.	Electric. 1 starter.	Do.
Do.	Do.	Cast iron.	Do.	Do.	Electric.	Do.
Steel.	Special steel : Monicro.	Light alloy.	Cast iron S.	Do.	Do.	Do.
Nick.-chr. steel.	Nick.-chr. steel.	Cast iron.	Cast iron L.	Do.	Do.	Do.
Do.	Do.	Aluminium.	Do.	Do.	Do. 1 starter.	Do.
Steel.	Special steel : Monicro.	Cast iron.	Cast iron S.	Do.	Electric.	Do.
Nick.-chr. steel.	Nick.-chr. steel.	Light alloy.	Cast iron.	Do.	Do.	Do.
Do.	High-strength steel.	Aluminium.	Special cast iron L.	Do.	Do.	Do.
Steel.	Special steel : Monicro.	Cast iron.	Cast iron S.	Do.	Do.	Do.
Nick.-chr. steel.	Nick.-chr. steel.	Aluminium.	Special cast iron L.	Do.	Do.	Do.
Special steel.	Special steel.	Light alloy or welded steel plates.	Cast iron L.	Do.	Electric or compressed air. Heating plug.	Compressed air.
Steel.	Special steel : Monicro.	Light alloy.	Cast iron S.	Do.	Electric.	Mechanical.
Special steel.	Nick.-chr. steel.	Silumin or aluminium.	Grey iron L.	Do. Dry sump.	Electric. Heating plug.	Do.
Nick.-chr. steel.	Do.	Cast iron.	Special very hard cast iron L.	Pressure.	Electric. 2 starters. Heating plug.	Do.
Special steel.	Special steel.	Do.	Cast iron L.	Do.	Electric.	Do.
Poldi steel.	Poldi steel.	Cast iron and Silumin.	...	Do.	Main generator.	...
...	Special steel.	...	...	...	Electric or compressed air.	...
Nickel steel.	Nick.-chr. steel.	Cast iron.	Cast iron L.	...	Electric. De-compressor. Heating plug.	Mechanical and compressed air.
Nick.-chr. steel.	Nick.-chr. steel. Tungsten.	Aluminium alloy.	Cast iron S.	Pressure. Jet nozzle in front of each bearing.	Compressed air.	Mechanical.
Special steel.	Special steel.	Cast iron.	Cast iron L.	Pressure.	Electric.	Do.
Do.	Do.	Steel.	Steel L.	Do.	Compressed air.	Do.
...	...	...	...	Pressure. Jet nozzle in front of each bearing.	Compressed air.	...
Nick.-chr. steel.	Chr.-mol.-nick. steel.	Aluminium.	Cast iron L.	Pressure.	Electric. 2 starters.	Mechanical.
...	...	...	...	Do.	Main generator.	Do.
Steel.	Special steel : Monicro.	Light alloy.	Cast iron S.	Do.	...	Do.
Special steel.	Special steel.	Silumin.	Grey iron.	Pressure. Dry sump.	Electric. Heating plug. De-compression.	Do.
Nick.-chr. steel.	Nick.-chr. steel.	...	...	Pressure.	Main generator.	...
Do.	Do.	...	...	Pressure. Jet nozzle in front of each bearing.	Do. Electric or compressed air. Heating plug.	Mechanical.
Do.	Do.	Steel.	Steel L.	Pressure.	Electric.	Mechanical.

Note. — S = Cylinders machined from solid casting.
L = Cylinders with lining.

The vibrations occurring at critical speeds must not be overlooked. By altering certain parts (in particular the crank shafts) and by very careful balancing (balancing each coupling by counterweights) the builders have succeeded in getting the speeds at which such vibrations are set up to lie outside the working speed range of the vehicle.

The less important vibrations have been suppressed by using dampers.

Lightness.

The present traction type of engine weighs some 6 kgr. (13.2 lb.) per H.P. The weight is being reduced all the time. This engine falls between the aircraft engine which must weigh less than 1 kgr. (2.2 lb.) per H.P. to be usable, and is expected to run only 300 hours between overhauls, and the stationary engine with which weight is unimportant. The lightness of the traction engine does not prevent it running 75 000 km. (46 000 miles) or 1 000 hours between repairs. These results are due to metallurgical progress on high-tensile light alloys, and to better design, through which the speed of the engines has been increased so much.

The above tendency is general, except in the Central European countries (Austria, Hungary and Czechoslovakia). These countries prefer heavy engines (10 to 12 kgr. = 22.0 to 26.4 lb. per H.P.) as they can be relied on to run 100 000 km. (62 100 miles) between repairs (guarantee given by GANZ).

Economy.

Like all other power producing units, the engine must be economical, especially as regards repairs and maintenance, as these equal and sometimes even exceed the fuel costs.

A saving of a few grammes of fuel per H.P. is very important in the case of a power station engine, working 24 hours a day; it is much less important in the case of the traction engine working intermittently.

Care must be taken not to obtain such savings by working the engine at its maximum power, as this would reduce its life at much greater cost. The cost of the engine repairs can be reduced by improving the life of the engine, by making it easier to take the engine down, and by making all its parts interchangeable.

Detailed investigation into rail motor coach Diesel engines.

The engines used vary from the lowest powers up to 450 H.P.

The smaller powered engines, under 120-H.P. motor lorry engines, although thoroughly satisfactory as the result of several years' development, are not powerful enough except for a few very light four-wheeled railcars (new Renault railcars which weigh 9 tons and have a 120-H.P. lorry engine).

The engine builders have therefore designed engines specially for rail motor coach use. They have either increased the power of existing patterns by increasing the number of cylinders (C.L.M. - GANZ - M.W.M. - M.A.N.), or introduced entirely new designs (M.A.N. 210 H.P.).

Generally speaking, these engines behaved well, as they incorporate the experience of builders engaged on similar work.

Whereas some makers have been able to increase the number of cylinders (the 210-H.P. M.A.N. became the 280-H.P. engine with two extra cylinders), other makers have not been able to do this, and have had to consider engines with the cylinders in two banks, either the V or the newer square type.

In the V-type engine the two groups of 6 cylinders are at 60° and drive a single crank shaft (220-H.P. RENAULT, 380-H.P. MAYBACH, BENZ).

In the second design, the two parallel lines of cylinders drive two crank shafts which in turn drive a central shaft usually coupled to the generator of an electric drive (400-H.P. M.A.N.).

Although it is too early to come to any final conclusions on these engines, these designs do, however, provide a way whereby the power can be increased as necessary whilst keeping the engine within the space available in a rail motor coach.

It should be noted that the Czechoslovakian Company *Brno Kralove Polska* has built a V-type engine of only 160 H.P.

Materials for and design of details.

As regards *materials,* high-tensile steels are used to a remarkable extent. The crank shafts and connecting rods are made from nickel-chrome, nickel-chrome-molybdenum, or nickel-chrome-tungsten steel.

Duralumin rods are being introduced.

The rods are nearly always I shaped. The rods for V-type engines are however tubular and are articulated about the large end.

Light-alloy pistons are generally used. Cast iron pistons are still used on the C.L.M. and GANZ engines.

The design of the top of the pistons and the cylinder heads depends on the type of injection and will be dealt with later.

The crank cases are cast iron, steel, or more often light alloy. The very well thought-out design of the 210-H.P. M.A.N. should be noted in this connection. The crank case is welded steel, fitted with inspection doors. The liners are dropped into position. The rods, pistons, and even a cylinder liner can be removed without completely taking down the engine.

The magnitude and nature of the forces set up in Diesel engines have compelled the builders to alter the usual petrol engine layout. The crank shaft bearings are tied to the cylinder head by through tie rods, so as to relieve the crank case from traction forces.

The top half of the crank case is stiffened and stayed by ribs which support the bearings.

The bottom half of the crank case only forms the oil reservoir, and carries the oil pumps.

Cylinder block castings are going out, and except for certain engines designed by GANZ, MAYBACH, and M.A.N. all the others use liners which are readily replaced, of steel (M.A.N. 210 H.P.), or more generally of special cast iron.

As the maximum pressures developed in Diesel engine cylinders exceed those of the petrol engine, friction about the crank shaft and big end bearings have required particular attention.

Most builders are using for the big ends and crank shaft bearings brasses lined with white metal (Hoyt, Synovia...). In other designs, the white metal is applied directly to the steel. It is not yet certain if this method will become general as certain difficulties have arisen (breaking away from the steel, and cracking) due possibly to excessive pressures per square inch or to technical difficulties in applying the white metal to steel. The tendency now is towards the use of new antifriction alloys of lead and copper melting at 1 000° C. (1 832° F.) (rose metal or lead bronze). When these anti-friction metals are used, the hardness of the journals must be increased (by local hardening).

MAYBACH alone uses roller bearings throughout; other builders find they set up additional vibrations. SAURER uses them for crank shaft bearings.

The piston pin is either floating, when it is prevented from moving sideways by soft metal discs, or by circlips, or is rigidly held on the piston or rod.

The piston rod small end is fitted either with bronze bushes or with needle bearings (of the NADELLA type).

Lubrication.

Pressure lubrication is used in all cases.

In the MAYBACH engine, with roller bearings, a rather special lubrication

system has to be used (see fig. 5). The oil from the crank case is driven through the oil filter (1) by the pump (2) into the revolving shaft (3) supported by the crank shaft bearing caps. Each journal on this revolving shaft is drilled so that the hole through the shaft is put into communication with a groove cut in each of the bearing caps and leading to a spray nozzle. The oil is discharged as the big ends pass them. This lubricates the big ends, the little ends, crank shaft bearings, and cylinder walls being lubricated by the oil thrown off the big ends.

In the other types of engine (fig. 6), the oil is forced under pressure by a pump (1) into the crank shaft through a passage which feeds the crank shaft bearings. The oil leaves the crank under pressure and lubricates the big ends (3) and, by splash, the little ends and cylinder walls.

Some builders, M.A.N., M.W.M., Mercedes-Benz and Ganz, lubricate the little end bearings by force feed. The oil from the big end passes either through a hole drilled in the rod or through a small tube fastened to the rod.

In the case of the Ganz engine, a large quantity of oil is discharged on to the underside of the piston head to cool it.

The majority of builders use the bottom of the crank case as the oil reservoir and fit one or several filters in the oil circuit. On certain engines built by C.L.M., Mercedes-Benz, M.W.M., and the Aciéries du Nord (Acenor engine under M.A.N. licence) and in the 210-h.p. M.A.N., the dry sump system is used, i.e. the oil as it drops onto the sump is forced by one or several pumps through the filters and a cooler into an auxiliary reservoir from which another pump forces it under pressure through the lubrication system.

On some engines, such as the 220-h.p. Renault and the Ganz, on which the bottom crank case is the oil reservoir, an oil cooler is fitted, either separated from or built into the engine, and the cooling water runs through it.

The cam shafts and auxiliary controls are lubricated as a rule by oil circuits branched off the main pressure line. Some builders lubricate the rockers under pressure and others leave the driver to do it by hand.

The designers, whilst improving the lubrication of the different parts of the engine, are now endeavouring to use the oil for cooling purposes. Much has still to be done to develop a satisfactory lubrication system with an oil which will retain its qualities for a long time and be used all the time at the best temperature, of some 80° C. (176° F.).

Injection.

The different engines we have to consider use one or other of the two systems of injection now employed : « air » or « pump ».

In spite of its good features as regards combustion, and therefore regularity of running, air injection is only used in the case of the 175-h.p. Maybach engine. This system is not used more generally because of the complication and weight and the room taken up by the compressor and air bottles.

As the injection area can be set proportionately to the quantity of fuel and the injection pressure to the number of revolutions (regulating the engine directly driven air compressor), with this system the engine can be arranged to meet all power and speed conditions. In other words the combustion is good and the engine is very flexible, which are great advantages in the case of traction engines.

All other builders use mechanical injection. The different designs used can be classified into three main groups :

1. *Direct injection.*

Used by the C.L.M., Renault (fig. 7), Aciéries du Nord, M.A.N., Maybach, Cesko-Moravska-Kolben-Danek, Brno Kralovo Polska.

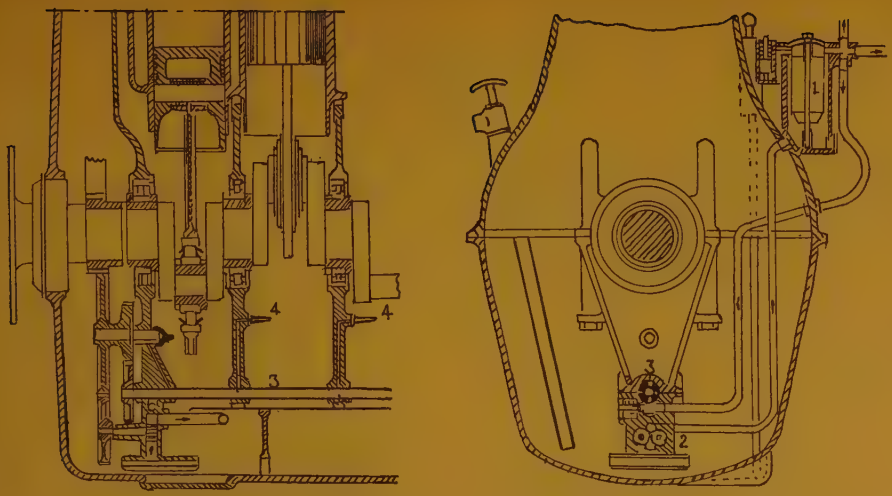


Fig. 5. — Lubrication of MAYBACH engine.

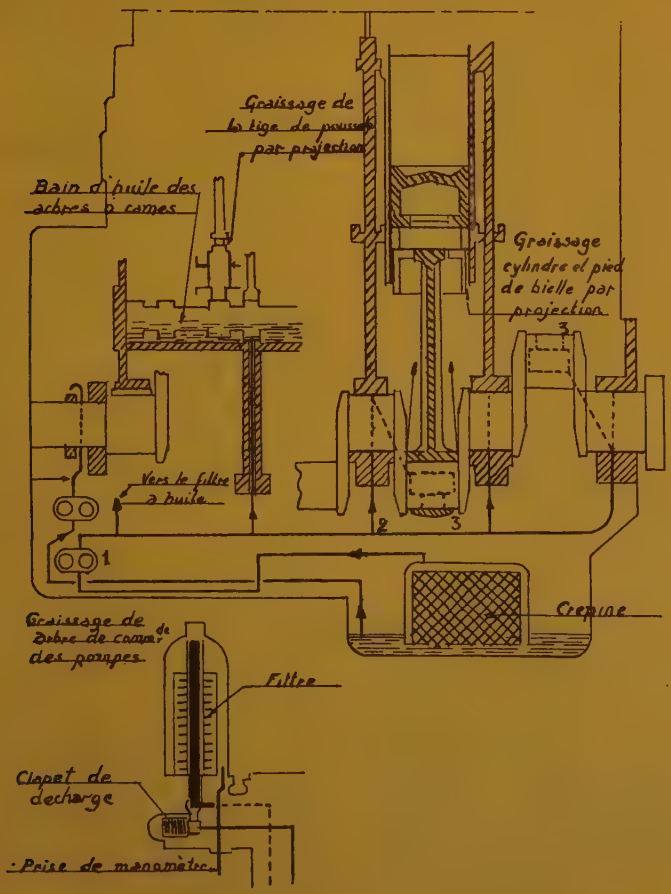


Fig. 6. — Lubrication of 100-H.P. RENAULT engine.

Explanation of French terms:

Graissage de la tige de poussoir par projection = Splash lubrication of tappet rod. — Bain d'huile des arbres à cames = Oil bath of cam shafts. — Graissage cylindre et pied... = Splash lubrication of cylinder and small end of connecting rod. — Vers le filtre à huile = Towards oil filter. — Graissage de l'arbre de commande des pompes = Lubrication of pump shaft. — Crépine = Strainer. — Clapet de décharge = Drain clap valve. — Prise de manomètre = Pipe towards gauge.

The fuel is injected into a compression chamber of more or less compact form, into which the whole of the combustion air is compressed.

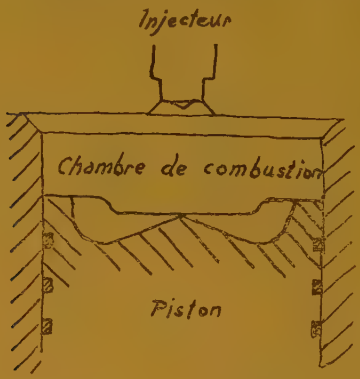


Fig. 7. — RENAULT engine.

This method has the merit of simplicity. If the combustion is to be good, the fuel must be pulverised very finely and be equally distributed throughout the chamber under all running conditions. This means injection pressures of 120 to 400 kgr. (1 700 to 5 700 lb. per sq. inch) with the following attendant drawbacks :

a) rapid wear of pump parts subjected to as much as 120 to 400 kgr./cm² (1 700 to 5 700 lb. per sq. inch) pressure and on which no play can be allowed, and

b) the gas oil has to be forced through extremely small orifices with the possibility of their choking up or the area of the orifices varying.

2. *Precombustion chamber used by* GANZ (fig. 8), MERCEDES-BENZ (fig. 9), M.W.M. and LORRAINE.

The fuel is injected into a precombustion chamber which opens in the compression space through a passage of varying form. The temperature, pressure, and composition of the gases in this precombustion chamber at the moment of injection depend on the proportions of the chamber and of the communicating passage. The fuel begins to

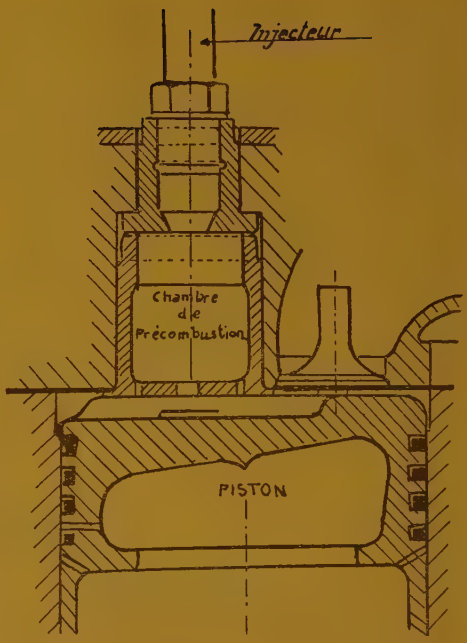


Fig. 8. — GANZ engine.

burn and the chemical changes to start in this chamber. The ensuing rise of pressure forces the mixture through suitably arranged and proportioned nozzles. This system claims to add, to the advantages of mechanical injection (details are light and take up little room), an air injection effect (better pulverisation and greater flexibility under different operating conditions).

Mechanically speaking, with this system much lower pressures [60 to 70 kgr. (850 to 1 000 lb. per sq. inch)] can be used, pump wear is reduced and the injectors have larger orifices less likely to choke up.

It should be noted that, owing to the injection first taking place into the precombustion chamber, which is surrounded by a fairly large mass of metal, and wherein the compression pressure is less than in the cylinders, a sufficiently high temperature cannot be obtained to start

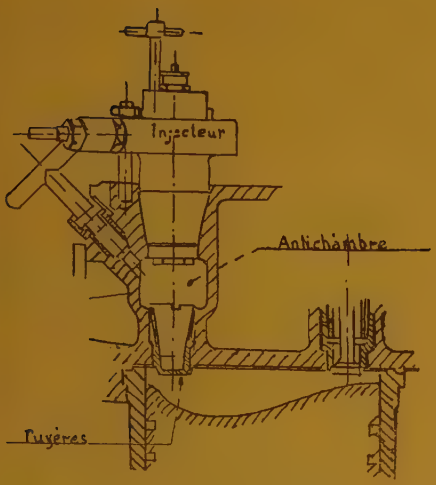


Fig. 9. — BENZ engine.
Precombustion chamber.

Note: Antichambre = Precombustion chamber.
Tuyères = Nozzles.

from cold properly. This difficulty is overcome by using heating plugs or a nitre impregnated wick.

3. *The air chamber* used on the SAURER engine (fig. 10) and the BERLIET (in

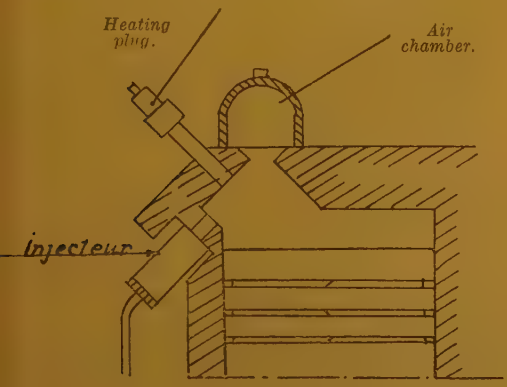


Fig. 10. — SAURER engine.

which it is incorporated in the piston). In this type of engine, a reserve of air is held in a chamber. As soon as the injection ceases, the pressure in the cylinders falls as the expansion has begun, and this reserve air issuing through the orifice completes the combustion which it activates by a scrubbing action.

This system gives a fuller, slower, and more progressive combustion than the direct injection method. The injectors are the same in both cases, the pressure being about 120 kgr./cm² (1 700 lb. per sq. inch).

Fuel pumps.

The fuel pumps are designed to maintain constant pressure from the start to the end of the injection period. The injection is arranged to begin and end suddenly.

The suction and discharge orifices are opened and closed in the BOSCH (fig. 11), C. L. M. and P. M. pumps by

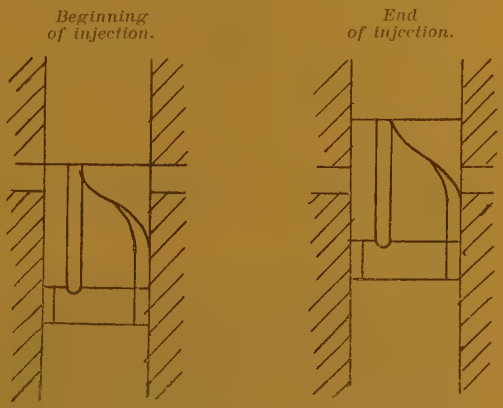


Fig. 11. — Working of BOSCH injection pump.

the piston acting as distributor, the quantity of oil injected being controlled by rotating the piston. In the M. A. N. pump the discharge only is controlled by the piston, an automatic suction valve being fitted.

In some instances the injection is stopped by a release valve opening.

An attempt has been made in the GANZ pump (fig. 12) to render the injection

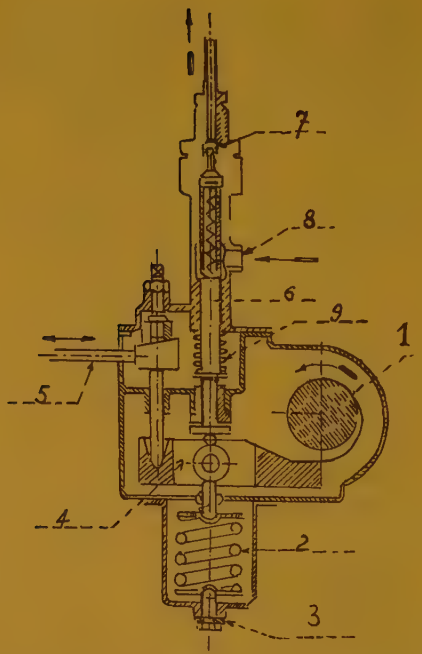


Fig. 12. — GANZ injection pump.

Explanation:

1. Cam.
2. Thrust spring.
3. Adjustment of spring.
4. Lever.
5. Control of injection.
6. Piston.
7. Retaining valve.
8. Intake.
9. Piston release spring.

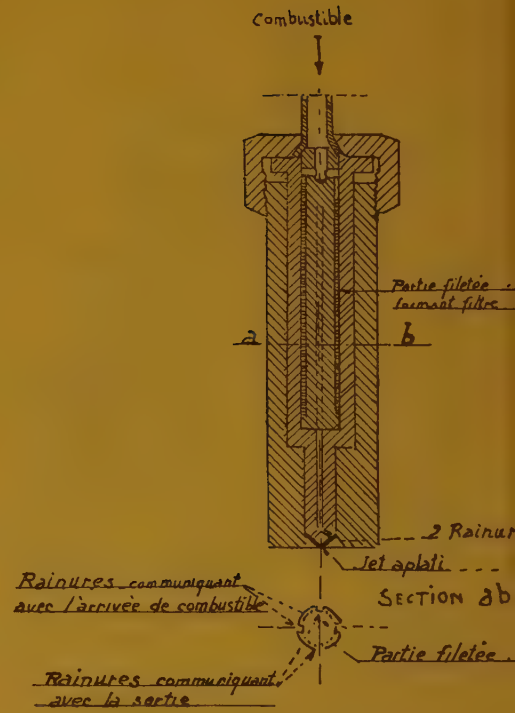


Fig. 13. — C. L. M. injector.

Explanation of French terms:

Combustible = Fuel intake. — Partie filetée formant filtre = Threaded part acting as a filter. — 2 rainures = 2 grooves. — Jet aplati = Flattened-out jet. — Rainures communiquant avec l'arrivée du combustible = Grooves communicating with fuel intake. — Section = Cross section. — Rainures communiquant avec la sortie = Grooves communicating with outlet.

pressure independent of the speed of rotation. The injection is due to the pressure of a spring which is compressed by a cam and suddenly released. The quantity of fuel being injected is varied by altering the stroke of the piston.

Injectors.

The injectors are either of the open type (C. L. M., fig. 13, GANZ) or with obstructing needle valves. In the latter case the needle held on its seat by a spring is lifted by the pressure of the fuel.

The designers have experienced much difficulty in preventing reflex pressure waves from opening the injector a second time without control. They have overcome the difficulty by suitably proportioning the injectors and piping.

Cylinder head design.

In all three systems of mechanical injection described above, the top of the pistons and the cylinder heads are of various shapes, selected to give better combustion.

Although many and ingenious designs have been got out, there is still room for much progress.

The designers are endeavouring to obtain good pulverisation of the fuel at

all speeds and loads. This is only possible when the injection pressure, the advance of the injection, the degree of turbulence, etc... are in agreement under all operating conditions.

Governing.

A governor is more necessary with the Diesel engine than with either steam or petrol engines.

It has to meet the following two cases:

1. — If there were nothing to control the air and fuel supply, the engine under certain conditions could run at speeds above the normal;

2. — At a given speed, as the volume of air in the cylinders is incompletely consumed under normal working conditions, the engine can develop a power exceeding the designed value, were more fuel to be injected.

The speed governors are based on centrifugal force and act directly (Bosch governor, fig. 14) or control through oil under pressure (Maybach engine) the quantity of gas oil injected. This action is governed by the accelerator control which acts either on the governor spring or by levers on the pump operating rods, either directly or by compressed air (M.A.N., fig. 15).

These governors allow a variation of about 5 % to 10 % between the maximum speed at full load and light.

To meet the second condition a stop is fitted in the pump to fix the maximum quantity of oil injected.

Starting.

The traction Diesel engine should start easily under all circumstances and not take much time to get ready.

As the rail motor coaches are fitted with very large batteries for lighting purposes, naturally enough the designers took the necessary current from them to work one or two electric starters according to the size of the engine. These starters are usually about 1.5 h. p., with sliding armatures, that is to say they only develop their full power when the pinions have engaged with the toothed ring by moving the armature along its axis.

Several methods are used to make it easy to start up :

1. The engine starting resistance is reduced by decompressors acting momentarily on all cylinders or on half of them only; or

2. The temperature of the air supplied to the cylinders is raised by nitre impregnated wicks or heating plugs.

In powerful traction engines such as the 175-p. h. Maybach or the 210-h. p. M.A.N., the engines are started by compressed air (the latter engine can also be started electrically).

In the M.A.N. engine a special valve controlled by the cam shaft admits air from compressed air bottles to the cylinders after reducing the pressure from 60 to 30 kgr./cm² (853 to 426.5 lb. per sq. inch).

When the engines are coupled to electric generators, the generator is usually used as starter motor.

Cooling.

All these engines are water cooled. The radiators are cooled either by the vehicle moving or by forced ventilation (fan driven by the engine) or by a combination of both methods.

The engines are usually fitted with thermostats or similar devices which control the water circulation and, by bypassing part of it, maintain the temparature of the water leaving the engine at about 80° C. (176 F.).

Lightness.

In this respect, the important characteristic is the weight per h.p. We have drawn up a table classifying these engines according to this ratio, and giving the normal r. p. m. of each.

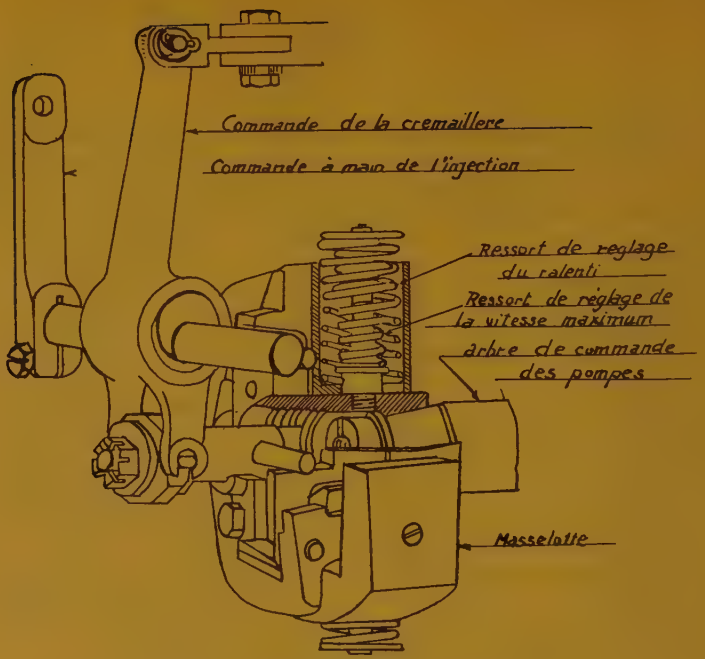

Commande de la cremaillere
Commande à main de l'injection
Ressort de reglage du ralenti
Ressort de réglage de la vitesse maximum
Arbre de commande des pompes
Masselotte

Fig. 14. — Bosch fuel pump governor.

Explanation of French terms:

Commande de la crémaillère = Control of rack. — Commande à main de l'injection = Fuel control hand lever. — Ressort de réglage du ralenti = Adjusting spring for slow speed (throttling down). — Ressort de réglage de la vitesse maximum = Maximum speed adjusting spring. — Arbre de commande des pompes = Pump shaft. — Masselotte = Head of casting.

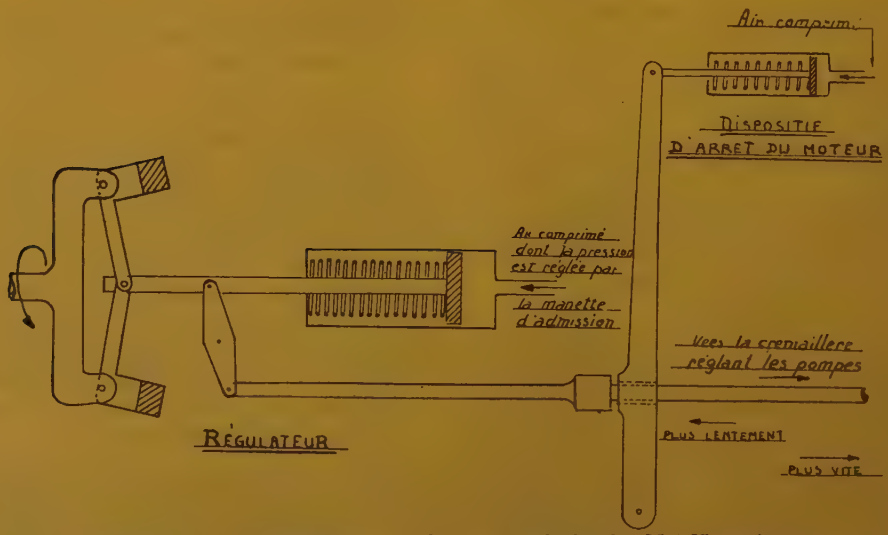

Air comprimé
DISPOSITIF D'ARRET DU MOTEUR
Air comprimé dont la pression est réglée par la manette d'admission
Vers la crémaillère réglant les pompes
RÉGULATEUR
PLUS LENTEMENT
PLUS VITE

Fig. 15. — Speed governor and stopping device for M.A.N. engine.

Explanation of French terms:

Air comprimé = Compressed air. — Dispositif d'arrêt du moteur = Engine stopping device. — Air comprimé dont la pression... = Compressed air the pressure of which is adjusted by the inlet lever. — Régulateur = Governor. — Vers la crémaillère... = Towards pump controlling rack. — Plus lentement = Slowing down. — Plus vite = Faster.

TABLE III.

NAME.	Engine H. P.	Weight per H. P. Kgr.	Weight per H. P. (*Lb.*)	Nominal speed r. p. m.
GANZ	110	17.5	*38.6*	1 000
GANZ	125	16	*35.3*	1 000
M.W.M.	175	15.7	*34.6*	800
M.W.M.	125	14.4	*31.7*	1 000
ACENOR, M.A.N. licence	170	13	*28.7*	900
CESKOMORAVSKA-KOLBEN-DANÈK	350	12.5	*27.6*	900
BRNO-KRALOVO POLSKA	160	12.5	*27.6*	1 300
DELAUNAY-BELLEVILLE, KRUPP lic.	65	11.8	*26.0*	1 000
M.A.N.	190	10.8	*23.8*	1 000
RENAULT 100 H.P.	100	10	*22.0*	1 500
BERLIET	125	9.4	*20.7*	1 500
M.A.N.	150	8.9	*19.6*	1 500
GANZ	220	8.4	*18.5*	1 200
SAURER	140	8.3	*18.3*	1 500
GANZ	130	8.1	*17.9*	1 350
GANZ	95	8.1	*17.9*	1 650
C.L.M.	100	8	*17.6*	1 500
MAYBACH	210	7.9	*17.4*	1 400
M.A.N.	420	7.5	*16.5*	1 400
MERCEDES-BENZ	135	7.4	*16.3*	1 700
RENAULT	220	7.1	*15.7*	1 500
C.L.M.	80	7.1	*15.7*	1 500
M.A.N.	210	7.1	*15.7*	1 400
LORRAINE	120	6.8	*15.0*	1 500
MAYBACH	175	6.3	*13.9*	1 400
MERCEDES-BENZ	300	6	*13.2*	1 500
MAYBACH	410	4.9 (1)	*10.8* (1)	1 400

(1) Weight of engine without clutch, flywheel, nor starter.

When engines of like design are examined, it will be seen that increased speed reduces very appreciably the weight per H. P.

NAME.	Engine H. P.	Weight per H. P. Kgr.	Weight per H. P. (*Lb.*)	Nominal speed, r. p. m.
M.W.M.	170	14.4	*31.7*	800
ACENOR (M.A.N.)	170	13	*28.7*	900
M.A.N.	190	10.8	*23.8*	1 000
M.A.N.	150	8.9	*19.6*	1 500

The metallurgists have put at our disposal materials of such qualities that, in conjunction with the improvements in design, speeds of over 1 500 r. p. m. for engines of about 125 H. P. are now possible.

Great improvements in the methods of injecting the fuel had to be made before such speeds were possible. The inertia of the pumps, gas oil in the pipes and injectors, had to be overcome, apart from the difficulty of ensuring combustion in about 1/500th of a second.

As two other engine factors, the lineal speed of the pistons (linked up with the speed of rotation) and the mean effective pressure, are increased, the weight per horse power falls. Lubrication difficulties, kinematic forces, and the strength of the parts appear at the present time to make higher speeds than 10 m. (32.8 feet) per sec. and a mean effective pressure of 7 kgr./cm² (100 lb. per sq. inch) impracticable.

Further reduction in engine weight can be obtained by using two-stroke cycle engines as they give 1.8 greater power than a four-stroke cycle engine of equal cylinder volume. This advantage also affects the space taken up. Moreover the two-stroke engine also has a simpler valve gear and has other good features, owing to the scavenging (the burnt gases are well swept out, there is slight supercharge, and the cylinder temperature is slightly reduced).

The practical difficulties (effective scavenging, high stresses in parts) are limiting the development of this type of engine, the JUNKERS (French licensee, C. L. M. Willème) and the BURMEISTER & WAIN (Belgian National Rys. Co.s rail cars) being the only ones at present used on rail motor coaches.

The JUNKERS two-stroke engine has pistons of cast iron and weighs 7.1 kgr. (15.65 lb.) per H.P.; as opposed pistons are used, the parts are not unduly stressed.

Last of all, we must not overlook the lightening possible when designing with this object in view. Light alloys used to the fullest extent, or welded steel construction for the engine, has made it possible for the M.A.N. 210-H. P. engine to weigh only 7.1 kgr. (15.65 lb.) per H. P.

* * *

CHAPTER III.

PART I.

Rail motor coach transmission gear.

One of the most difficult questions in connection with the use of the heat engine for rail motor coach work is the transmission of the power of the engine from its crank shaft to the wheels of the vehicle. The problem is in fact to provide a liaison between the wheels the speed of which can vary between enormous limits, 0 to 120 km. (75 miles) an hour, for example, and the crank shaft of the heat engine, the number of revolutions of which, for constructional and economic reasons and for durability, should not vary much from an optimum figure.

The system of transmission therefore cannot be a simple mechanical intermediate motion, such as the connecting rods of the steam engine, but must be a true energy converter.

When dealing with powers of several hundred H. P., electric transmission so far seems to be preferred by the builders and the railways, even though some builders consider hydraulic drive the transmission of the future.

However, for medium powers (150 to 300 H. P. according to the case), mechanical drive has the advantage of being

less costly, lighter and more efficient. Builders of electric transmission gear nonetheless stress, for low powers, the reliability of their equipment over a long period, and the hydraulic gear makers the very high efficiency of their transmission on direct drive.

It would be premature to come to any conclusion on the merits of these gears at present. It should be noted, however, that a good transmission gear ought to enable the driver to control it from a distance, without any physical effort. In this connection it will be shown hereafter that the builders of all three forms of drive have designed satisfactory distant-operated controls, some of which have solved the problem in a remarkable manner.

Before describing the different forms of drive, we think we should make a few general remarks on the way these transmission gears make use of the engine power at different coach speeds.

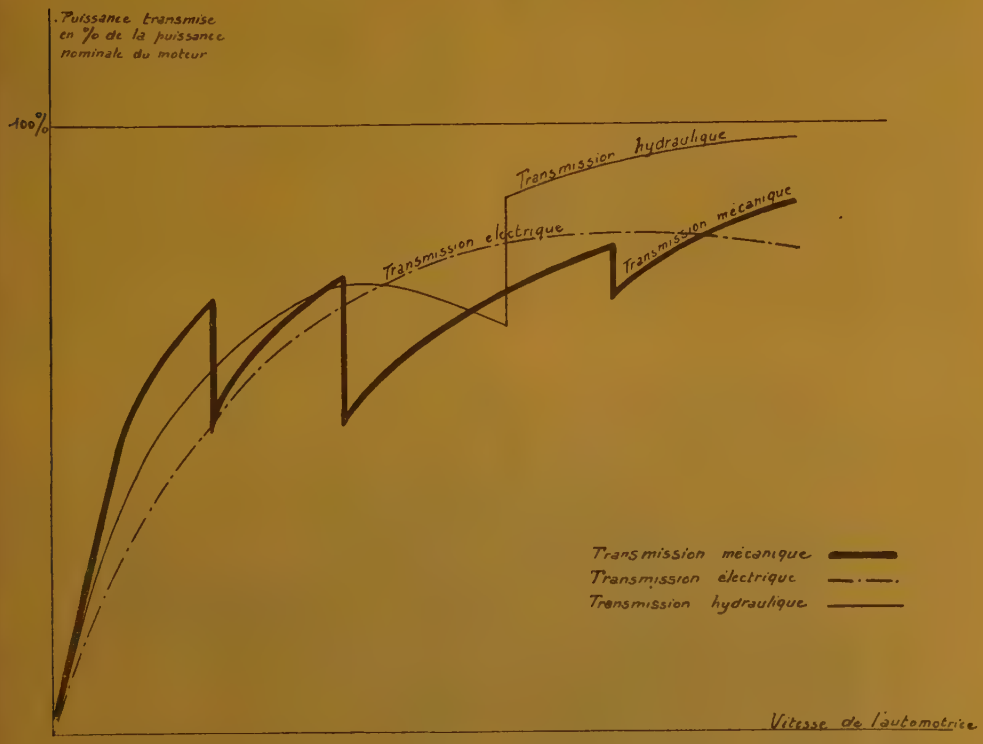


Fig. 16 showing how the different transmissions make use of the engine power.

Note: Puissance transmise... = Power transmitted, as a per cent of the nominal engine power.
Vitesse de l'automotrice = Railcar speed.

As shown by the diagram (fig. 16), with electric transmission the power curve is very regular and increases with the speed to a certain maximum, after which it generally falls off. The mechanical drive is seen to give sudden changes in power as the gear is changed. The hydraulic drive shows a great variation

in the power transmitted when going over from the converter to direct drive.

These curves clearly show that a better efficiency should not be claimed off hand for a given transmission as compared with another. For two given forms of drive, the efficiency depends entirely on the speed of the rail motor coach. In practice, we should take the efficiency over the starting period, or the efficiency at the maximum engine speed. When dealing with the efficiency over the starting period, we must be careful to take into account lost time (time lost through declutching or slipping the clutch, etc...), when changing gear in the case of mechanical drive, or for coupling in the case of hydraulic transmission.

The aforementioned diagram is schematic and any general conclusions, such as that at maximum speeds the mechanical drive has a higher efficiency than electric transmission, must not be drawn from it. There are cases which are just the contrary.

PART II.

Mechanichal transmission.

1. General.

The different systems of mechanical drive used on rail motor coaches include as a rule the following parts after the engine :

clutch,
gear box,
reverse gear,
drive of one or more axles.

These parts are usually connected by shafts with suitable joints, or, but more rarely, by chains. Their respective position naturally depends on the type of rail motor coach.

Mechanical drives differ considerably in layout according as they are for four-wheeled or bogie vehicles. They vary again in bogie vehicles according to the position of the engine : on the bogie or on the main frame. It will nonetheless be possible to describe hereafter a number of parts which may be common to most rail motor coaches with mechanical transmission.

In some cases the transmission gear and engine are in one unit (RENAULT) which is easily removed for repairs.

When a motor coach is not reversible, no reverse gear is fitted, but instead an additional speed in the gear box.

In some designs of gear box, each train of gears is fitted with its own clutch (MAYBACH) or acts as a separate clutch (WINTERTHUR), the main clutch in this case being as a rule suppressed.

Occasionally the following devices are included in mechanical drives :

free wheel,
differential,
constant-ratio speed reducing gear.

* * *

General remarks on each part of the drive are given below.

Clutch.

Nearly all clutches are of the multiple dry-plate type usually used in automobile practice. When the clutch is in, the discs are held together by coiled springs arranged in parallel to the centre line of the drive. The clutch is operated mechanically or by compressed air.

In some cases the clutch pedal also operates a transmission brake, which acts on the driven shaft.

Gear box.

There are two principal types of gear box :

1. constant-mesh gears;
2. sliding gears.

In the first type, each train of gears consists of a wheel keyed to its shaft

and another wheel free on its shaft. The loose wheel can be coupled to its shaft by a dog clutch (Fiat) or a separate clutch (Ganz). When a dog clutch is used, the dog and the gear are brought to the same speed before they are meshed together. This is called synchronised gears. The dog clutches are operated mechanically or pneumatically.

When there is a separate clutch for each train of gears (T. A. G.) the clutch is usually of the disc type, compressed-air or pressure-oil operated.

In connection with constant-mesh gear boxes, certain boxes making use of the valuable properties of epicyclic gears should be mentioned. In such boxes, one element of the train of gears giving the desired speed is held stationary, either by an electro-magnetic clutch (Cotal) or by a mechanical brake (Wilson).

The sliding-gear boxes are of the automobile type, the gears being changed mechanically or pneumatically. Such boxes are used on the lowest-powered rail motor coaches (Skoda, Czechoslovakian rail motor coaches).

As the gear box is heavy and costly, the design is based on the torque and not on the power to be transmitted. High-speed engines should therefore be preferred so that at equal power the torque is as small as possible. The speed of the engine however also affects its weight and, therefore, the weight of the rest of the motor coach, thereby increasing the weight to be hauled, and reducing the maximum speed possible for a given power.

Reverse gear.

Two main types are used :

1. Bevel gears (cf. fig. 17) consisting of a bevel pinion driven by the engine and constantly in mesh with two bevel wheels mounted loose on their own shaft, which is at right angles to the shaft carrying the pinion. A mechanically or pneumatically-operated dog

Fig. 17. — Reverse gear with bevel wheels, of the Mylius transmission.

clutch slides on the cross shaft and couples this shaft to one or other of the two bevel wheels. In this way the driven shaft is driven in the desired direction.

2. Reverser using idler gears (cf. fig. 18) in which the power is transmitted to the driven shaft either directly by two straight gears for forward running or through one or several idler wheels which reverse the direction of rotation for back running. The reverse gear is fitted either in front or behind the gear box, and in some cases is combined with the gear box. It is as a rule built in with the axle gear.

Axle drives.

The power is usually transmitted to the wheels by pairs of bevels.

In some cases, such as the MAYBACH-RENK, the engine crank shaft drives a loose axle by connecting rods.

Finally, some builders (B. D. R.) use chains to drive the axles by sprocket wheels keyed on the axles.

Free wheel.

A free wheel device is fitted on some railcars; the coach can then be run down gradients without the engine being driven by the transmission. This device protects the engine and isolates it from the transmission in the event of misuse of the gear.

* * *

Below is given a brief description of a certain number of mechanical transmissions on rail motor coaches now in service. Constant-mesh gear boxes will be described first, and then those with sliding gears.

2. Constant-mesh gear boxes.

a) *Skoda drive.*

The SKODA drive (fig. 18) used on the rail motor coaches built by this firm for the Turkish State Railways consists of :

main clutch,
gear box,
reverse gear,
horizontal cardan shaft driving the axles through bevels.

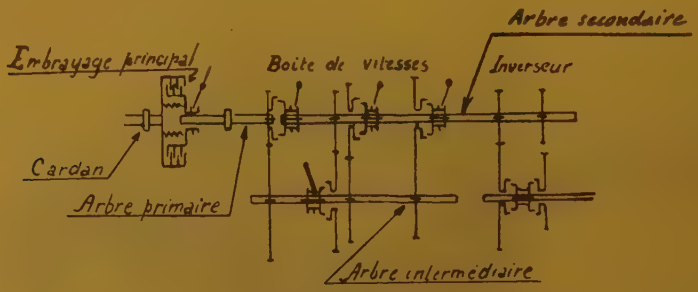


Fig. 18. — SKODA transmission for Turkey.

Explanation of French terms:

Embrayage principal = Main clutch. — Boîte de vitesses = Speed gear box. — Arbre secondaire = Driven shaft. — Inverseur = Reverse gear. — Cardan = Universel joint. — Arbre primaire = Main shaft. — Arbre intermédiaire = Lay shaft.

The main clutch is of the multiplate dry type. In the gear box there are three parallel shafts, the first driven by the engine, a secondary shaft in line with the first, and an intermediate shaft. The three shafts carry four trains of gears always in mesh, giving four speeds.

The reverse gear is embodied in the

speed gear box, the drive being taken through a lay shaft.

b) *Mylius drive.*

The MYLIUS drive (figs. 19 and 20) consists of :

main clutch,
gear box,
cardan shaft,
reverse gear, and
axle driving gear.

The main clutch is of the multiplate dry type.

The clutch is withdrawn by compressed air.

The Mylius gear box has three main shafts :

a primary shaft driven by the engine,
a driven shaft K, fitted as an extension of the former, and
an intermediate shaft parallel to the two first.

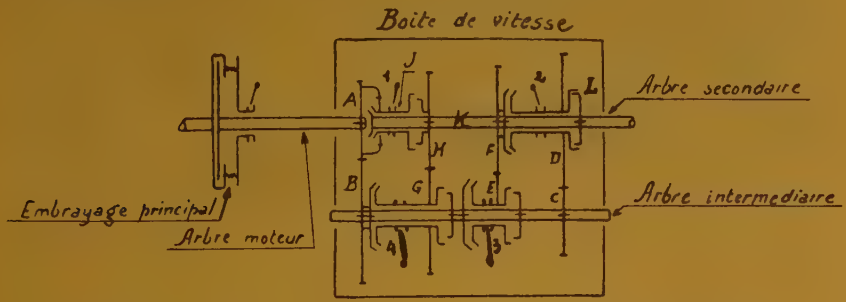


Fig. 19. — MYLIUS transmission. (The reverse gear is not shown.)

Fig. 20. — MYLIUS gear box.

The shafts carry four trains of constant-mesh gears consisting of pinions A and B, C and D, E and F, G and H.

The pinion A has inside and outside teeth, and is integral with the primary shaft.

Pinions B, C, F and H are keyed to their shaft.

Pinions D, E, and G are free on their shaft and can slide along it. Sleeve J too is free on shaft K and is constantly in mesh with the inner teeth of pinion A.

The sliding pinions and the sleeve J are moved by selector gear with forks 1, 2, 3 and 4.

Each of the loose pinions D, E and G and the sleeve J have, on the left side, a cone friction clutch and, on the right side, a half claw coupling.

Keyed to the driven shaft K there are : on the left end a cone clutch plate, on the right end a half claw coupling L, and on the intermediate shaft between wheels E and G a part with a half claw coupling on the left side and a cone clutch plate on the right side.

To engage a particular gear the corresponding loose wheel is moved to the left and this engages the cone plate on this wheel with the corresponding bearing on the keyed wheel on its left, and causes the moveable wheel to run at the speed of its shaft. The moveable wheel is then moved back to the right and thanks to the speed synchronism so obtained, the claw coupling is easily engaged.

The figure shows the position of the gears for the first speed.

The reverse gear is by bevel gears operated pneumatically.

The complete Mylius, transmission for 330 H.P. at 1 500 r.p.m. weighs 1 590 kgr. (3 505 lb.).

The firm has already supplied 95 boxes for powers of 50 H.P. and over, and has under construction 125 boxes for powers of from 75 H.P. and over.

This gear is used on rail motor coaches of the German State Railways and on the de Dietrich rail motor coaches belonging to the French Main Line Companies.

c) *Transmission using the S. L. M. Winterthur gear box.*

The S. L. M. Winterthur gear box (figs. 21 and 22) usually has four speeds.

Four pinions corresponding to the four speeds are keyed on the primary shaft and are in constant mesh with the corresponding wheels on the secondary shaft.

Each wheel on the secondary shaft is formed of two rings D and includes its own clutch which works as follows :

The hubs of two coupling discs E are mounted on the secondary shaft A and can slide along it, but not turn on it.

The two rings D forming the wheel are loose on the hubs of the two discs E, but cannot move longitudinally.

Circular V-shaped grooves are cut in the coupling discs E and the rings D to fit into one another.

An oil pump driven by the primary shaft supplies oil under pressure to work the clutch.

A distribution valve controls the amount of oil admitted and is so arranged that only one clutch can be worked at a time.

When engaging a gear, the oil under pressure admitted through the passage C of the secondary shaft A penetrates between the discs E and forces them apart until each couples with the corresponding rings D. The secondary shaft is thereby gradually driven by the train of gears considered.

When declutching, the oil between the discs E is exhausted and the discs are forced together by the back pressure of the oil admitted in the chambers H by the passage B and the orifices F and I.

When starting, the oil pressure is reduced so that the first speed is gradually engaged.

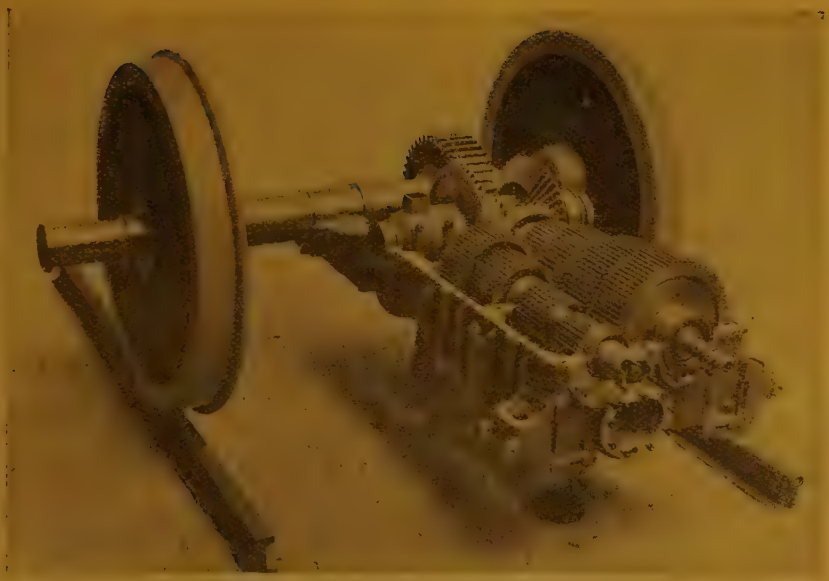


Fig. 21. — WINTERTHUR gear box.

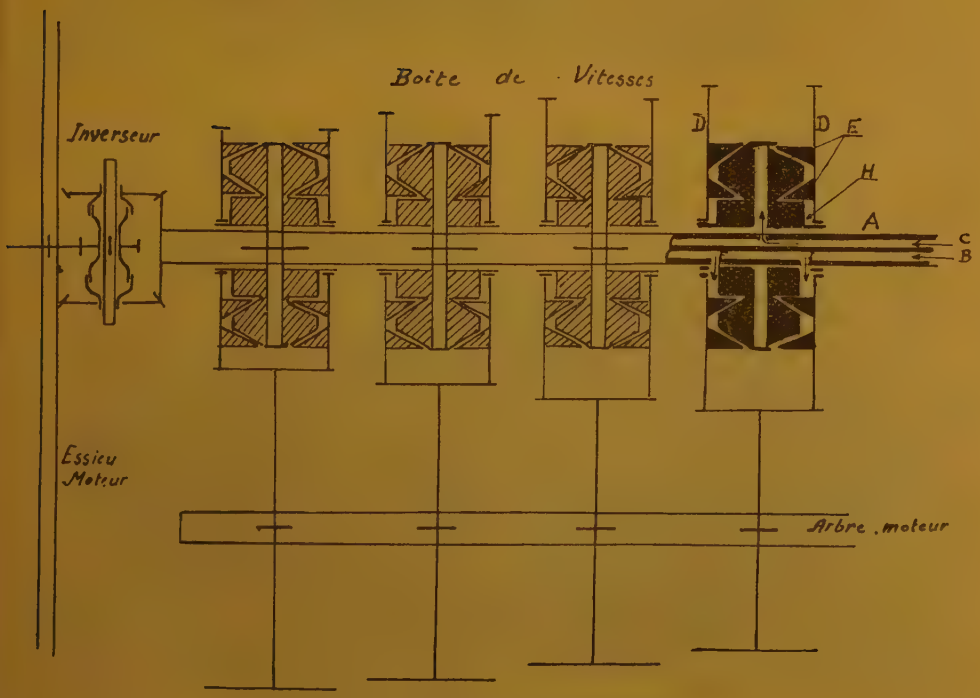


Fig. 22. — WINTERTHUR transmission.

Note: Inverseur = Reverse gear. — Boîte de vitesses = Gear box. — Essieu moteur = Driving axle. Arbre moteur = Main shaft.

The S. L. M. Winterthur four-speed gear box on the Decauville rail motor coach of the French Nord Railway includes, in the same casing, the reverse gear of the usual straight pinion type.

The reverse gear has three parallel shafts. The first is coupled by chain to the second shaft of the gear box, and the third drives the driving axles. The drive is direct in one running direction; in the other there is a wide intermediate wheel. The reverse is obtained by a pneumatically-controlled dog clutch sliding on the third shaft.

On the four-wheeled P. L. M. coach built by the Compagnie Française de Matériel de Chemin de fer, the S. L. M. Winterthur four-speed box located at the centre of the frame drives the secondary shaft with universal joints which in turn drive the driving axles through bevel gears.

The reverse gear, in the driving axle casing, has bevel gears.

The Winterthur transmission for transmitting 300 H.P. at 1 500 r. p. m. weighs 1 890 kgr. (4 166 lb.) including the reverse gear.

The Winterthur Company has now 100 speed boxes in service, and 54 on order for powers of 150 to 300 H.P.

d) *Fiat transmission gear.*

This drive has a four-speed constant-mesh gear box; the speeds are engaged by two pneumatically-operated dogs.

The reverse gear is located behind the free wheel, has bevel wheels, and is pneumatically controlled.

The weight of a gear box transmitting up to 120 H.P. at 2 000 r.p.m. is 286 kgr. (630 lb.), including the compressor drive box, the clutch control cylinder and gear case.

The compressor weighs 27 kgr. (59.5 lb.). Messrs. Fiat have now 94 gear boxes in service for engines of 120 H.P., and 130 boxes under construction, for 75-H.P. and 100-H.P. engines.

e) *Ganz transmission gear* (fig. 23).

This box gives 5 speeds in each running direction. The gears are always in mesh and are pneumatically operated. The reverse gear on some rail motor coaches is of the straight gear type, and in others bevel wheels are used.

The GANZ transmission gear, with the gear box in Nickalum for 275 H.P. at 1 200 r.p.m., weighs 1 200 kgr. (2 645 lb.) not including the reverse gear.

The same gear with cast iron box weighs 1 500 kgr. (3 300 lb.).

Messrs. Ganz now have 139 gear boxes for 60 to 275 H.P. in service; 61 boxes for 95 to 275 H.P. are in hand.

f) *Maybach transmission gear.*

The MAYBACH gear box (fig. 24) is controlled by oil under pressure; it has four speeds with four trains of gears, each with its own clutch.

The reverse is with bevels.

The total weight of a 210-H.P. Maybach transmission at 1 400 r.p.m. is 2 300 kgr. (5 070 lb.).

This firm has delivered 103 boxes for 150 to 210 H.P., and has 20 boxes in hand for the same range of powers.

g) *Minerva transmission gear.*

The speed gear box of this transmission has five gears, the first sliding and the others constantly in mesh. Mechanichal control is fitted.

Reversing is by gears in the gear box.

h) *Renault transmission gear* (fig. 25).

The RENAULT gear box is a four speed constant-mesh box, the speeds being selected by two dogs mechanically controlled.

Reversing is through bevel wheels.

The Renault gear box can transmit 250 H.P. at 1 500 r.p.m. and weighs 360 kgr. (793 lb.). The reverse gear, free wheel and motion with bevel gear wheels weigh 560 kgr. (1 234 lb.).

40 Renault transmissions have now

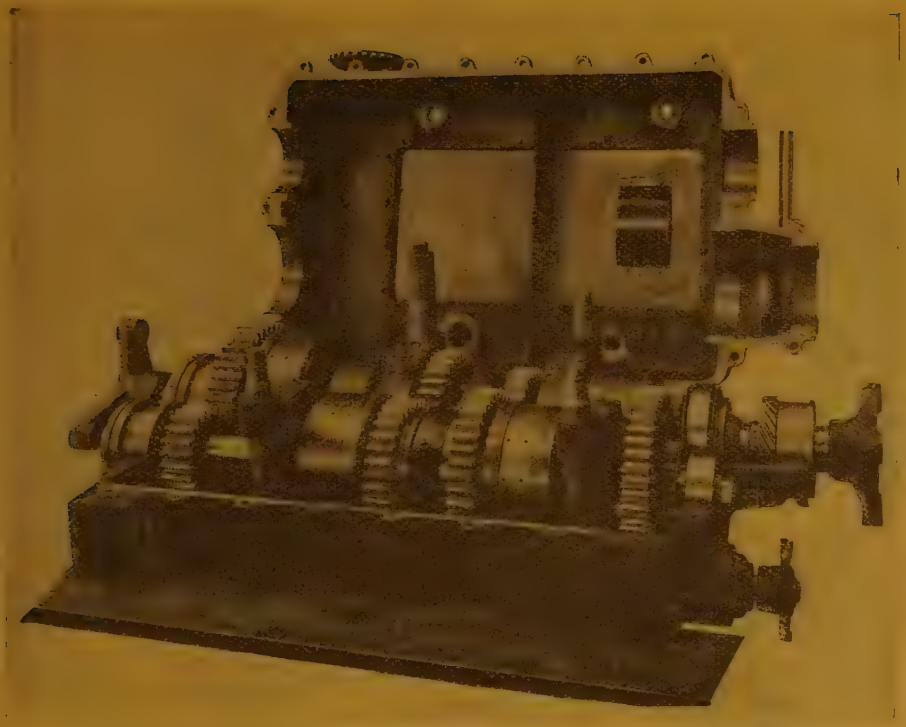


Fig. 23. — GANZ gear box.

Fig. 24. — MAYBACH gear box, 210 H. P.

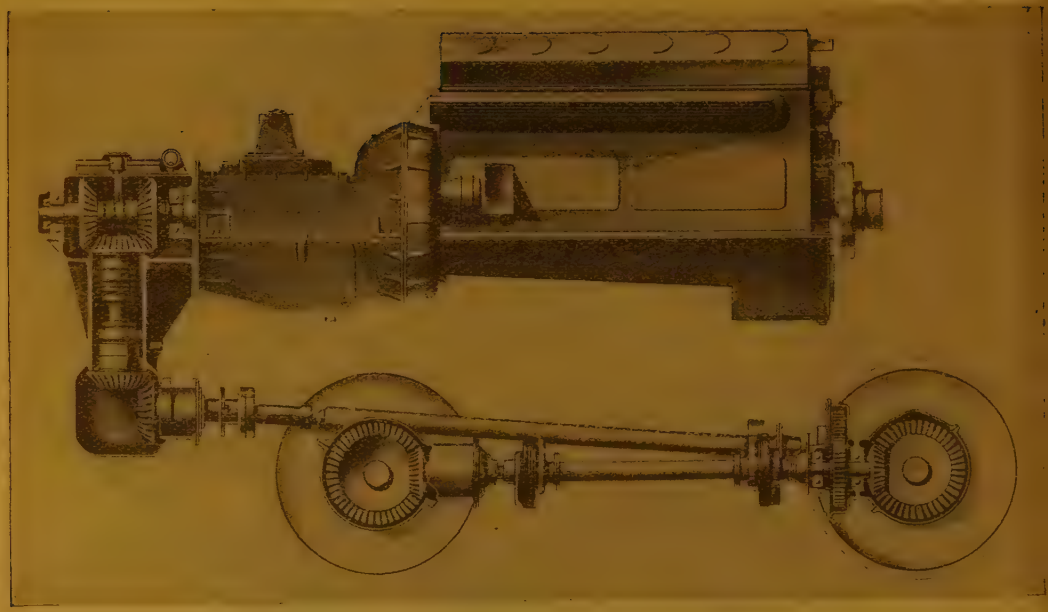


Fig. 25. — RENAULT transmission, 220 H. P.

Fig. 26. — T.A.G. gear box.

been supplied and 80 are under construction.

i) *T.A.G. transmission gear.*

The T.A.G. gear box (fig. 26) gives four speeds in each direction. The gears corresponding to each speed are locked to their shaft by individual friction clutches pneumatically operated.

The total weight of the T.A.G. gear for

250 H.P. at 1 500 r.p.m. is 1 600 kgr. (3 527 lb.).

The T.A.G. Company has supplied 400 gear boxes, and has 43 in hand.

3. Transmission with epicyclic gear boxes.

a) *Baudet, Donon, Roussel transmission with Cotal electromagnetic gear box.*

The transmission gear on the rail motor coaches built by Messrs BAUDET, DONON, ROUSSEL for the Paris-Lyons and Mediterranean, Paris-Orleans, and Nord Railways incorporate the following parts :

multiplate clutch of the dry plate type,
cardan shaft,
reverse gear,
gear box,
speed reduction gear,
chain drive to the driving axle.

The bevel wheel type reverse gear is electromagnetically operated.

The COTAL gear box has two shafts, the primary and the secondary, placed in line with one another at right angles to the longitudinal centre line of the coach (fig. 27).

Each shaft carries a train of epicyclic gears with multiple planet wheels in constant mesh.

In the first train, the central pinion

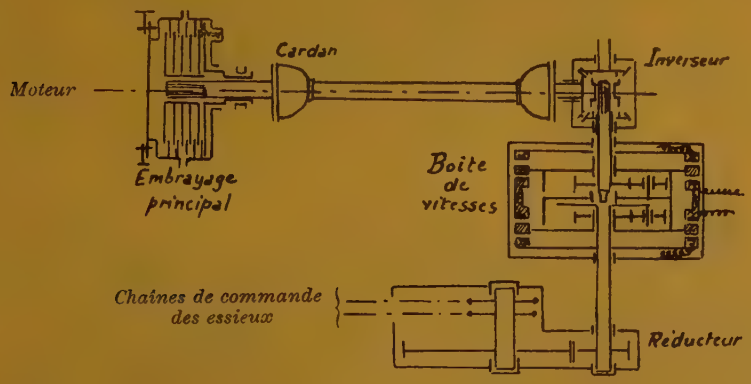


Fig. 27. — COTAL gear box.

Note : Chaîne de commande des essieux = Axle driving chain. — Réducteur = Reduction gear.

is keyed to the primary shaft. The internal toothed ring freely mounted on this shaft can be locked to it by exciting one or other of the electromagnets surroundig it.

The plate carrying the planet wheels, in the second train, is rigidly fastened to the secondary shaft; the central pinion free to revolve on this shaft carries a plate which can be held locked by one of the electromagnets round it.

The plate carrying the planet wheels of the first train and the internal toothed ring of the second train form a single unit free to turn on the line of the shafts.

There are four electromagnetic clutches giving four speeds.

On direct drive, the two epicyclic trains form a block and the gears turn as a whole without relative movements. In the event of the current failing, the first speed can be locked mechanically.

A reduction gear (two Citroen chevron gears) is fitted behind the gear box. The secondary shaft of this gear carries two sprockets for a double roller chain

which in turn drives two sprockets on the driving axle.

The COTAL box, without the reverse gear and the casing weighs 230 kgr. (507 lb.) and transmits 135 H.P. at 1 700 r.p.m. The firm has already supplied 19 boxes for 100 to 135 H.P. and has 4 more boxes for the same range of power under construction.

b) *Wilson gear box.*

This box contains a number of trains of epicyclic gears (fig. 28). The desired speed is obtained by locking the rim

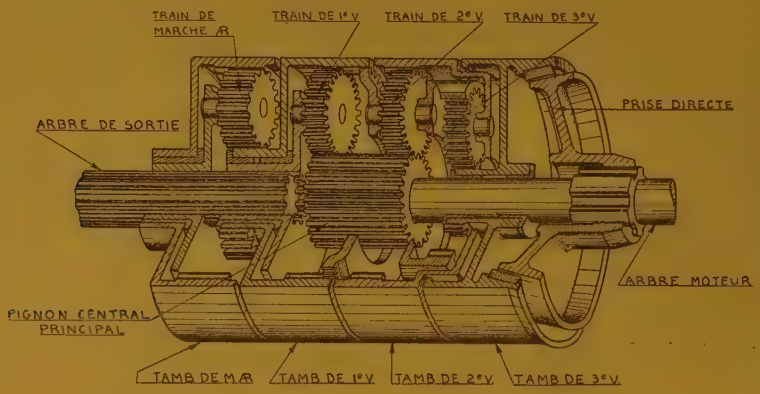


Fig. 28. — WILSON gear box.

Explanation of French terms:

Train de marche AR = Reverse running gear. — Train de 1° v (2° v, ... 3° v) = First (2nd..., 3rd...) speed gear. — Arbre de sortie = Driven shaft. — Prise directe = Direct drive. — Pignon central principal = Central main pinion. — Arbre moteur = Main shaft. — Tamb de M AR = Reverse gear drum. — Tamb de 1° v (... 2° v, ... 3° v) = First (2nd..., 3rd...) speed drum.

of the corresponding train of gears by balanced brakes. These brakes are operated mechanically. The desired gear ratio can be preselected and is brought into use by pressing down the clutch pedal.

The fourth speed is the direct drive, when the whole of the gears revolves as a unit without relative movement of the parts.

The Wilson box is fitted on the 120-H.P. rail motor coaches built by the BREDA Company for the Italian State Railways.

4. — Transmission gear using sliding gears.

When a sliding gear box is used, the same parts are included in the transmission as in the gears dealt with above:

clutch,
gear box,
reverse,
cardan shaft, and sometimes differential.

The rail motor coaches built by the Compagnie Générale de Construction de Saint Denis, for the Paris-Lyons and Mediterranean Railways, are fitted with multiplate clutches of the dry-plate type. A clutch stop brings to rest the driven member and is controlled by the clutch pedal when the latter has travelled 4/5ths of its stroke.

The mechanically-operated gear box has three sliding gear wheels giving four speeds forward and one reverse.

Bevel gears are used for the reverse gear.

In the case of the Paris-Lyons and Mediterranean rail motor coach built by Messrs. DELAUNAY-BELLEVILLE, the dry-plate clutch is followed by the reverse gear of the ordinary lay shaft type; four speeds can be obtained.

5. Other transmission gears.

a) *S.O.M.U.A. gear.*

The S.O.M.U.A. six-wheeled articulated reversible rail motor coaches of the French State Railways are fitted with a 210-H.P. Diesel engine at 1 400 r.p.m.

The drive includes :

a Fieux type clutch,

a non-slipping clutch coupling with Belleville washer,

sliding gear box,

free wheel,

reverse gear,

two driving shafts each driving its axle through bevels.

Fieux clutch (fig 29).

This clutch combines two distinct fittings.

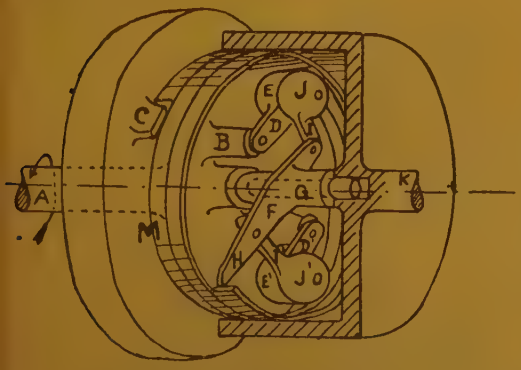


Fig. 29. — FIEUX « conjoncteur ».

The first, the « conjoncteur » is a slipping device with large surfaces; the friction takes place between the inside surface of a cylindrical drum fastened to the driven shaft, and a coiled spring driven by the engine. This coiled spring is subjected to centrifugal force tending to bring it into contact with the face of the drum, and to the force of the engine acting in the opposite direction. The fitting works in oil and is automatic. When starting the engine, power is transmitted with some slip until the engine speed becomes steady at a low speed corresponding to maximum power. When the vehicle speed corresponds to this speed, the two parts come together and the engine can be accelerated up to its normal speed.

The other fitting, the coupler, is a friction clutch with heavily loaded faces so that the driven member has little inertia. It is not required to slip and is operated just as an ordinary clutch.

As a result of this double equipment, we have :

Easy change of gear owing to the small inertia of the coupler, no great skill being required. Any slipping occurs automatically in the first fitting (the « conjoncteur »).

Loss of engine speed through overloading or mishandling the gears is limited to a certain value at which the two fittings separate.

The slipping device is designed to stand several minutes' slip under full load. The heat taken away by the oil is dissipated through the casing of the revolving part.

The Fieux clutch has made it possible to use the ordinary sliding or dog clutch gear box with engines of 200 H.P. or over.

Free wheel (fig. 30).

A spring R fastened to the gear box secondary shaft E winds up on a nut B. When the shaft E revolves more quickly than the shaft F, the spring tightens up on the nut B and drives it at its own speed. The nut B then forces part A forward by sliding on splines which prevent it turning relatively to D. The dogs on A and C come together and F is driven by E. If E revolves more quickly

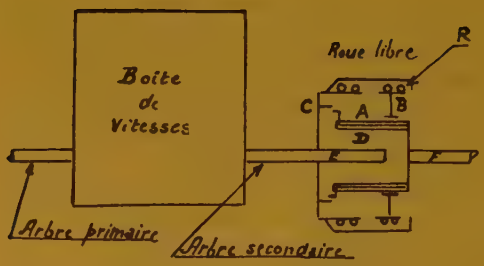


Fig. 30. — Free wheel.

Note: Roue libre = Free wheel.

than F, the reverse occurs. A pneumatic lock is provided to lock the free wheel in the driving position.

b) *Bugatti drive without gear box.*

The BUGATTI drive is used on the high-speed rail motor coach of the French State Railways (fig. 31) and on those ordered by the Alsace-Lorraine and Paris-Lyons and Mediterranean Railways.

Its main feature is that there is no gear box.

The coach has four 200-H.P. engines arranged transversely. Each engine has an oil-hydraulic clutch followed by a reverse gear (fig. 32).

Clutch.

The hydraulic clutch of the DAIMLER type, has two plates *a* and *b*, each with 24 radial vanes *c* and *c'*. One of these plates is driven by the engine, the other is secured to the shaft and the reverse.

When starting, the liquid is set in motion by the moving plate *b*, circulates through the cavities *c* as shown by the arrows, and acting on the upper part of the vanes *c'* of the plate *a*, tends to drive this latter.

Some slip, about 1 % in normal work-

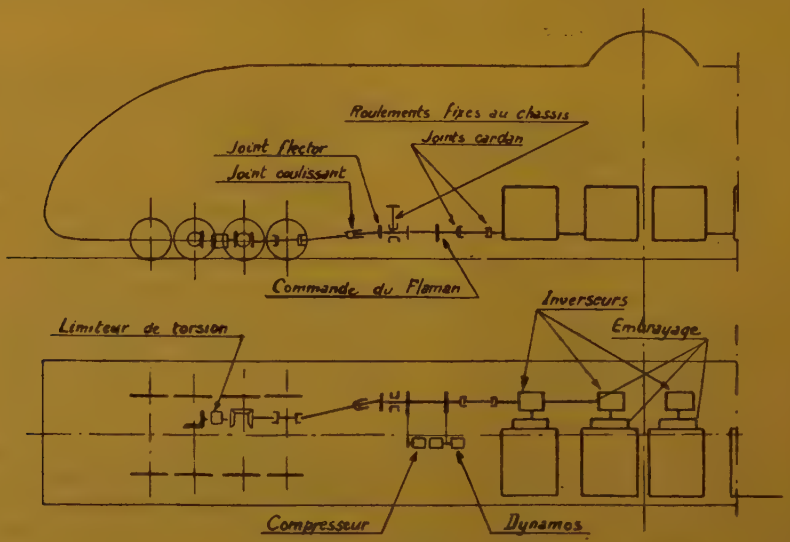


Fig. 31. — BUGATTI railcar. Diagram of mechanical transmission.

Explanation of French terms:

Roulements fixes... = Fixed roller bearings on frame. — Joint flector = Flector joint. — Joint coulissant = Sliding joint. — Joints cardan = Universal joints. — Commande du Flaman = Drive of Flaman recorder. — Limiteur de torsion = Torque limiter. — Inverseurs = Reverse gear. — Embrayage = Clutch. — Compresseur = Compressor.

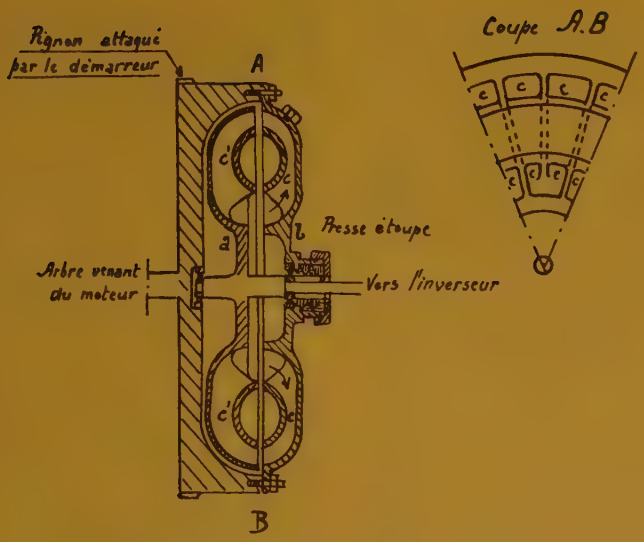


Fig. 32. — DAIMLER hydraulic clutch.

Explanation of French terms:

Pignon attaqué par le démarreur = Pinion driven by starter. — Coupe A.B. = Section A.B. — Presse-étoupe = Stuffing box. — Arbre venant du moteur = Main shaft. — Vers l'inverseur = To reverse gear.

ing, has to take place between the two plates if the clutch is to transmit the engine power.

The pressure difference in the cavities *c* and *c'*, due to the difference in speed of rotation, ensures that the liquid flows in the direction indicated by the arrow.

Bevel gears are used for the reverse.

Line of shafts.

The rest of the gear consists of a line of shafts from each pair of engines to the corresponding bogie.

This line of shafts is supported by an intermediate roller bearing on the coach frame, and is fitted with flexible joints, both sliding and universal. It passes through an opening formed in the inner axle of the bogie (which is fixed as on a road motor car) and drives through bevels the two driving axles between which there is a torque limiting device.

Each engine can be run independently so that the coach can be driven by one, two, three or four engines.

PART III.

Distant control on rail motor coaches with mechanical drive.

The injection pumps of the Diesel engine, the gear box, the reverse or the clutch on rail motor coaches, are distant-controlled :

A — mechanically,
B — pneumatically,
C — electro-pneumatically, or
D — electrically.

A. — Mechanical control.

When mechanical control is fitted the parts to be operated are connected to levers or pedals through rodding or metal cables.

In the case of four-wheeled rail motor coaches, or coaches with the engines on the bogie, there is no difficulty in arranging this control, even when there are two driving compartments. In this case the controls are interlocked and

cannot be misused, as the driver takes the driving handle with him when leaving the driving compartment.

When mechanical control has to be fitted to a bogie rail motor coach with Diesel engines on the bogies, a special layout is necessary, owing to the relative movement of the bogies. An example of this control is found in the Decauville rail motor coach of the French Nord Railway.

This two-bogie coach is fitted with Winterthur gear boxes. The engines are controlled by a pedal which operates the rack of the injection pump through rods.

When transmitting the motion from the body to the bogie the longitudinal movement of the rods is turned into rotary movement about their centre line. This rotary movement is then transmitted tho the bogie through a cardan shaft with two universal, and one sliding, joints.

The same lever operates the rack controlling the injection pump on the opposite bogie. The rodding works in tension so as to avoid any whipping.

Very little movement is required to operate the distribution valves of the Winterthur gear boxes but great precision is needed. The control through levers or rods therefore operates a helicoidal gear which transmits its movement by a cardan shaft, two universal joints, and a sliding joint to the valves as in the control of the injection pump.

With this control gear, all parts are rigidly connected and the driver cannot cut out an engine if he wants to. If he has to, he must stop and first of all put the reverse gear into neutral, which can only be done under special circumstances on account of the work involved.

In addition to mechanical control by rods, metal cables are also used. The 175-H.P. Maybach motor coaches of the Belgian National Railways are controlled by steel cables. The reverse, fuel pump, and gear box are each controlled by an endless cable connecting the control drum to the wheel keyed to the fitting to be operated. The cables are guided by reversing pulleys.

To get accuracy of movement, the cables are replaced by chains at the fittings.

Springs and tensioning devices are fitted to keep the cables in tension and to take up bogie movement.

The de Dietrich Company also uses steel cables on the rail motor coaches it built for the Alsace-Lorraine Railways.

On this type of coach, the 2 Mylius gear boxes are controlled by an endless cable which operates the gear lever of each box. This synchronises the different operations.

The clutches have each a compressed air servo-motor fed by the same feed valve distant controlled by a steel cable from the control pedal.

Besides the cable controls, we must mention the CORSET A. D. N. system used on the Paris-Orleans rail motor coaches built by the Aciéries du Nord de la France.

The CORSET transmission consists of a slightly flexible metal tube in which is threaded a string of beads formed alternatively of small barrels and small ovoids in hardened steel shrunk on a steel cable. This string of beads slides freely but without play in the metal tube.

Through the tension in the inside cable and the jamming of the barrels and ovoids a longitudinal movement in both directions can be transmitted at any point on the string of beads.

Each driving compartment is fitted with an arrangement which turns a sprocket wheel which gears with the string of beads, the displacement of which is communicated, at a suitable point along the tube and by a similar engagement, to another sprocket wheel which operates the equipment being controlled.

These devices show that rail motor

coach builders have been able to design a satisfactory distant control for operating the different fittings, even when the coach has two driving compartments and two motor bogies, with the engines on the bogie.

These controls are positive and safe. It must be noted, however, that mechanical control means a well trained staff as well as considerable effort, generally out of proportion to the work done. Multiple-unit working is out of the question when mechanical control is fitted.

B. — Pneumatic control.

When pneumatic distant control is used, compressed air servo-motors consisting of a cylinder with a piston working therein operate the different parts.

The compressed air is admitted to one or other face of the piston by a distributor valve which in some cases regulates the pressure. The piston movement controls the operation of the fitting concerned.

This servo-motor has been used with different gear boxes as we shall see in the descriptions below.

Distant control of the Fiat, Breda, and Somua six-wheeled rail motor coaches (fig. 33).

These rail motor coaches are all fitted with pneumatic distant control.

Speed gear control. — The gear boxes have as many compressed-air servo-motors as there are speeds. The servo-motors are connected by a two-valve distributor giving the following combinations:

1st valve position 0: neutral,
position 1: 1st speed,
position 2: 2nd speed;
2nd valve position 0: neutral,
position 3: 3rd speed,
position 4: 4th speed.

The zero position of the valves is central, so that to go from speed 1 to speed 2 it is necessary to go to neutral, which releases the gear in engagement. The two valves are mechanically interlocked to prevent any wrong movement. The driver has a check of the actual position of the gear by lamps which are either alight or out.

The reverse gear has two air cylinders, the pistons operating the fork mov-

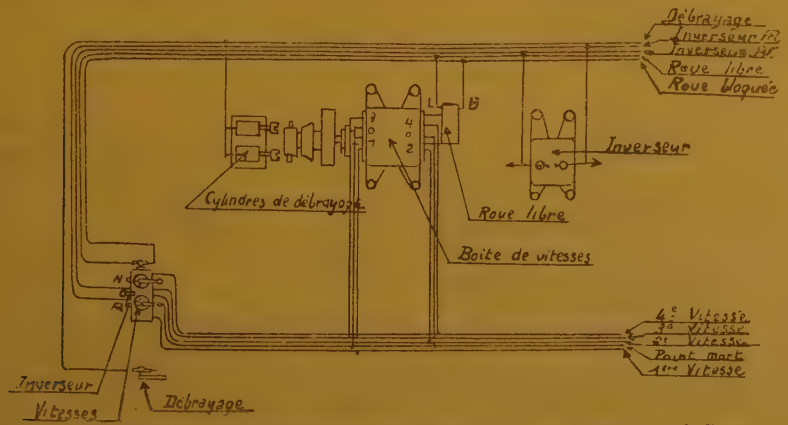


Fig. 33. — Arrangement of pneumatic control gear of Fiat, Breda and Somua railcars.

Explanation of French terms:

Débrayage = Declutching. — Inverseur AR = Reverse running. — Inverseur AV = Running forward. — Cylindres de débrayage = Declutching cylinders. — Roue libre = Free wheel. — Roue bloquée = Wheels driven. — Boite de vitesse = Gear box. — 4e (3e.., 2e.., 1re...) vitesse = 4th (3rd.., 2nd.., 1st..) speed. — Point mort = Neutral point

ing the dog clutch. These air cylinders are controlled by a three-position valve, the centre position opening the cylinders to the atmosphere. This valve is mechanically interlocked with the two gear box control valves so that the car cannot be reversed when a gear is engaged. The position of the reverse gear is repeated by a witness lamp supplied with current by a switch in the reverse gear box.

The clutch is controlled, like the reverse gear, by two air cylinders. Before changing gear it is, of course, necessary to declutch.

The injection pumps and the governor are controlled by an air cylinder. This cylinder is fed through a hand-operated pressure reducing valve by means of rods and levers. The driver regulates at will the air pressure in the cylinder and so controls the stroke of the piston.

Figure 34 shows the arrangement of this control.

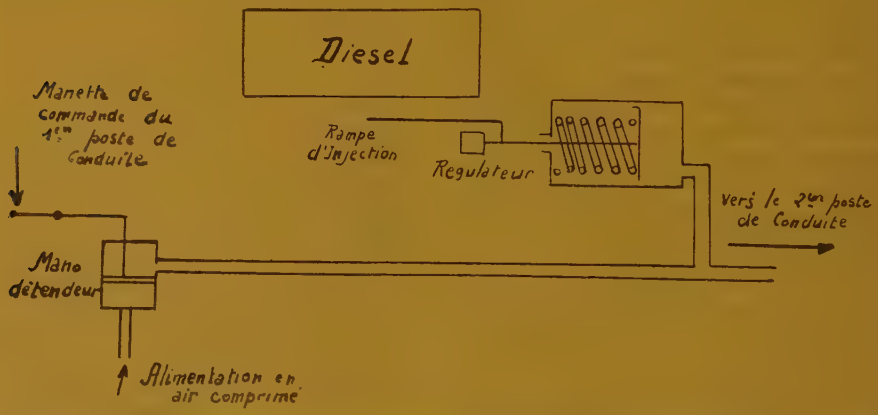


Fig. 34. — Layout of pneumatic fuel injection control on FIAT, BREDA and SOMUA railcars.

Explanation of French Terms:

Manette de contrôle du 1er poste... = Control handle of first driving compartment. — Rampe d'injection = Injection pipe. — Régulateur = Governor. — Vers le 2e poste de conduite = To 2nd driving stand. — Mano-détendeur = Pressure reducing valve. — Alimentation en air comprimé = Compressed air supply.

The rail motor coach having two driving compartments, in each of them there is a valve for shutting off the controls. In addition the reverse gear handle, when put into the neutral position, can be removed and this locks the gear box and clutch control.

The two compartments are connected together by pipe lines on the frame.

Control of injection pumps on the Aciéries du Nord rail motor coach for the Paris-Orleans Railway.

This rail motor coach has mechanical drive and is designed to run at a relatively constant speed, no matter what the profile of the line may be.

The governor control is based on there being equilibrium between the axial thrust of a mass rotating at the same speed as the engine and that of the piston on which compressed air acts after its pressure has been dropped by the driver by means of a regulating cock. At each of its displacements, the piston acts itself on the injection pump rack.

Control of the clutch and fuel pumps Baudet, Donon, Roussel system, on the reversible twin motor coaches of the Paris-Lyons and Mediterranean, Paris-Orleans, and French Est Railways.

The control is pneumatic. It consists of a compressed-air servo-motor acting on the fork operating the sliding clutch plate.

The progressive movement of this sliding clutch plate is governed by a pedal-controlled valve. When the pedal is pushed down compressed air is allowed to escape from the main reservoir at a pressure proportional to the force exerted by the pedal. The piston thus exerts a force on the fork proportional to that exerted by the driver. The pedal is interlocked with the change speed gear selector and makes it necessary to declutch when changing gear. It is also connected pneumatically to a valve which applies the brake, should the pedal be let go, thereby providing the safety device known as the dead man's handle.

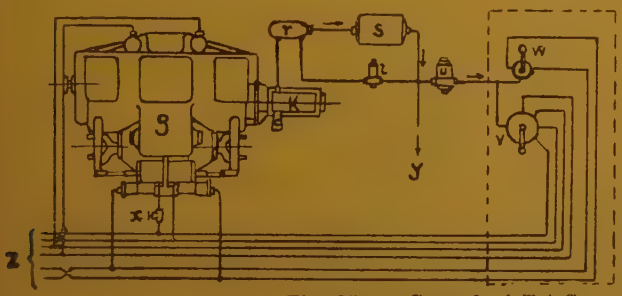
The fuel pumps are also pneumatically operated. A pressure reducing valve controlled from each driving compartment by lever and rods feeds air from the main reservoir at a pressure proportional to the movement of the said lever, to a servo-motor with a cylinder and a series of concentric pistons of different diameters, the stroke of each being limited by adjusting nuts. These pistons transmit their movement to a control spindle coupled to the fuel pump. This spindle is spring loaded.

This equipment provides the control for a rail motor coach with an engine on each bogie, or two rail motor coaches coupled together, whilst the driver can use one or other engine at will.

When two motor coaches are coupled together, the valves on the leading coach feed the clutch and pump servo-motors on the second coach under the same conditions. The valves on the second coach are cut out, at the same time as those of the direct acting brake and the main reservoirs, by a lever on the frame.

Distant control of the T. A. G. gear box (fig. 35).

The constant-mesh T. A. G. gear box has a friction clutch for each train of gears. The moveable part of each clutch is operated by a compressed air servo-motor, built into the gear box, the servo-motor consisting of a cylinder and a piston acting on the clutch through a lever.



g = Gear box.
k = Compressor.
r = By-pass reservoirs.
s = Main reservoir.
t = Adjustment of pressure.
u = Pressure reducing valve.
v = Four-way cock.
w = Reversing cock.
x = Adjusting valve for smooth throwing into gear.
y = To compressor.
z = To 2nd driving compartment.

Fig. 35. — Control of T.A.G. gear box.

These servo-motors are pneumatically controlled on rail motor coaches running as separate units or hauling very small rakes of stock. In this case, each driving compartment is fitted with a four-way valve distributing compressed air to the servo-motors. The valve is connected to the servo-motor by piping on the coach.

The reverse gear in this box also in-

cludes two compressed-air servo-motors controlled by a valve. The diagram shows the layout of this distant control. The compressed air is supplied by a compressor automatically controlled with a maximum pressure valve as well as a light running valve when the maximum pressure has been reached.

The first speed gear cylinder is fitted with a valve controlling the compressed air supply, so as to get a very gentle start. This valve can be set as required, and when changing from 1st to 2nd speed it also allows the air to be exhausted straight to the atmosphere, without passing through the valve in the driving compartment. This arrangement makes it possible to effect a quicker change of gear.

C. — Electro-pneumatic controls.

Electro-pneumatic controls have been developed from the pneumatic controls and the compressed air servo-motors are based on the same principle. The air is admitted to the cylinders through electro-valves through which current from a battery of accumulators flows.

The electro-pneumatic control lends itself very well to the different combinations to be made and is very useful when the rail motor coach has to haul a trailer or when two rail motor coaches are coupled together.

The electrical action is so rapid that there is perfect synchronisation when changing gear.

Jourdain-Monneret electro-pneumatic distant control fitted to the Delaunay-Belleville rail motor coaches of the Paris-Lyons and Mediterranean Railway, and the two Renault coaches of the French State Railways.

With this equipment the distant control of the change speed gear, the reverse gear, the clutch, and fuel pumps of a twin reversible rail motor coach with one or more engines is possible. Only the pumps are pneumatically controlled, and not electro-pneumatically.

The compressed air servo-motors of the different controls are fed by a set of electro-pneumatic valves worked by a controller with two drums. The first operates the change speed gears, with stop and intermediate positions, and the second controls the forward and back running.

The speed drum is operated by a handle hinged in the vertical plane and normally held upwards by a spring. The handle can occupy four positions corresponding to the excitation of each of the electro-valves of the speed gears, with a series of notches which have to be passed to get into the next higher or lower gear, the clutch being released after the desired gear has been selected.

This mechanical use of notches prevents the driver gearing up too quickly, just as it stops him gearing down at too rapid a rate.

Provision is made for declutching instantaneously in case of danger, and for preventing the driver from restarting in the gear in which he was when he stopped.

The injection pumps of the Diesel engine are controlled by a handle on the master controller operating a special valve which sends compressed air into a servo-motor with a piston counterbalanced by a tared spring. This piston moves proportionately to the angular displacements of the valve handle and controls the fuel pump.

When running with several engines or in multiple units the electro-control valves are fitted in parallel and an equipment can be cut out by opening the switches on the return circuits of the electro-valves.

A.E.G. electro-pneumatic control (fig. 36)

The A.E.G. electro-pneumatic control differs from the Jourdain-Monneret by the control of the fuel injection pumps

of the Diesel engine, which in this case includes five electro-valves, acting on the governor.

The diagram shows the layout of the equipment.

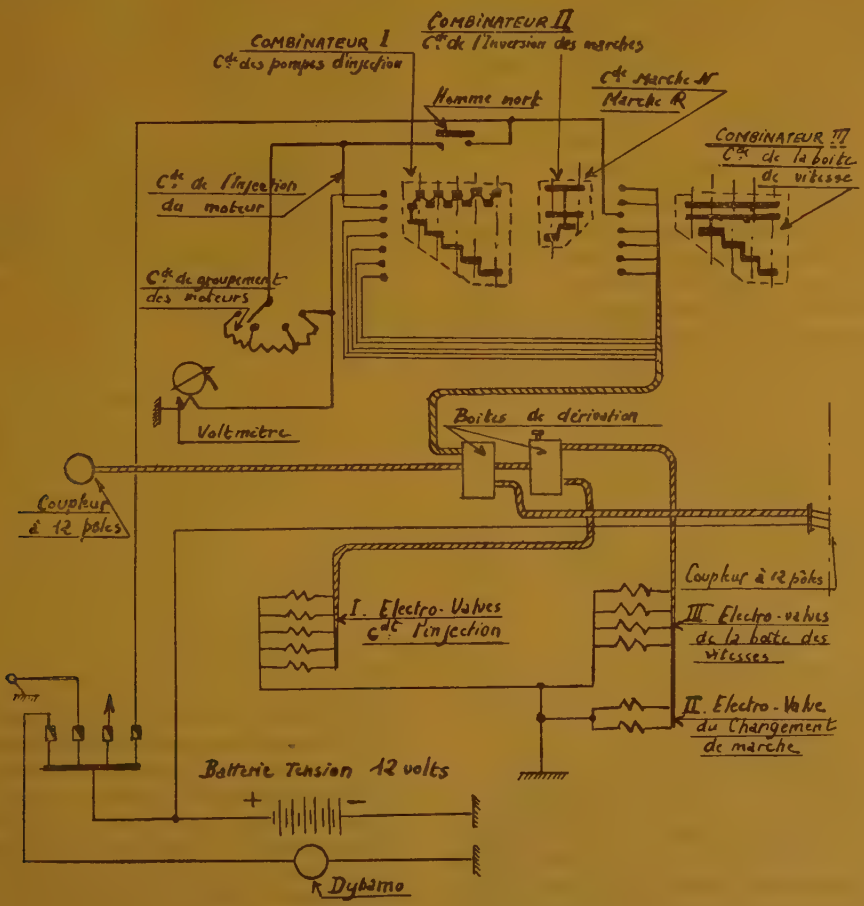


Fig. 36. — Layout of electric control of a railcar with mechanical drive (A.E.G. system).

Explanation of French terms:

Combinateur I (... II..., III) = Switchbox I (... II..., III). — Cde des pompes d'injections = Control of injection pumps. — Cde de l'inversion des marches = Control of forward and reverse running. — Marche AV = Foregear. — Marche AR = Reverse running. — Commande de l'injection du moteur = Fuel injection control. — Cde de groupement des moteurs = Control of engine grouping. — Boites de dérivation = Junction boxes. — Coupleur à 12 pôles = 12-pole circuit closer. — Electro-valves cde l'injection = Electro-valves controlling the injection. — Electro-valves de la boite de vitesse = Electro-valves of gear box. — Electro-valves du changement de marche = Electro-valves of reverse gear.

The driver can use as many engines as is necessary by a grouping rheostat.

Messrs. Baudet, Donon, Roussel have improved the electro-pneumatic distant control of the reverse gear on their coaches.

In this arrangement the electro-valves are fed separately or together and consequently forward, backward, or neutral positions can be obtained.

The fork operating the dog clutch is fitted with a rocker operating switches which shut off the current from the electro-valves as soon as the dog clutch is engaged.

D. — Electric control.

Electric control has been little used up to the present. There is one particular application, however, to the control of the COTAL gear box which is electromagnetic. The gear is changed by two selectors (one in each driving compartment) on the same support as the drum controlling the change speed gears and setting up the combinations corresponding to the four speeds in the box.

Moreover, by a mutual interlock, the speed control drum can only effect the four changes when the reverse gear is in forward running. In back gear, the speed gear drum can only give the first speed and is locked in the neutral position when the reverse gear is in the « stop » position.

Further, the speed drum can only be operated when the driver presses down the declutching pedal.

Distant-operated electric controls have also been used to work the governors of Diesel engines in some electrical drives with a limited number of running positions (Oerlikon drive, for example, of the Compagnie Française de Matériel de Chemins de fer). These gears embody electro-magnets with plungers acting directly on the governor springs.

* * *

Generally speaking, it seems that on recent rail motor coaches pneumatic or electro-pneumatic control gear are given the preference when the engines are mounted on the bogies, or the coaches are to be run as multiple units.

Pneumatic control is particularly advantageous in the case of mechanical transmission for controlling the fuel pumps. It allows of all speeds from the slowest to full power being obtained, as it acts progressively on the engine governors, whereas when electro-pneumatic control is used it is necessary to proceed in steps.

The reverse gear can be distant-operated by electro-pneumatic gear satisfactorily, though this is rather costly ; however, it gives all the combinations and interlockings required when operating a rail motor coach with one or several engines.

* * *

CHAPTER IV.

Electric transmissions.

An electric transmission consists of a direct-current generator directly coupled to the heat engine and series wound traction motors taking current from the generator.

The working of the rail motor coach (speed, tractive effort, etc.) depends, as in all direct-current traction, on the regulation of the voltage at the motors.

On motor coaches on electrified lines with constant line voltage, the voltage is regulated by inserting resistances in the traction motors' circuit or by changing the method of coupling up the motors.

On Diesel-electric rail motor coaches, as the generator is carried thereon, such methods are not necessary. It is just as simple and cheaper to vary the vol-

tage of the generator by acting on the excitation or on its speed.

The different methods of regulating this action result in the different types of electric transmission to be dealt with briefly below.

It should be remembered here that, for a given quantity of fuel injected, the torque of a Diesel engine is constant within a reasonable margin of speed. On the other hand, it has only a limited range of speeds and consequently of powers at which the quantity of fuel in question can be used economically.

The engine can only run if its torque exceeds the torque of the generator (resistant torque) as in the inverse case the engine would stall. Then too, for steady running, these torques must be adjusted to one another the whole time.

Now, the torque of the Diesel engine depends on the fuel charge alone, as we have already pointed out.

The resistant torque of the generator, approximately proportional to the product of its field by the current it delivers, depends on these two factors which for a given engine torque should vary inversely, that is to say according to the equation of a hyperbola. Now the current cannot be acted upon directly, as the traction motor circuits will generally not be interfered with. This means that the flux of the generator has to be controlled by altering either the speed of the motor-generator group or the excitation of the generator.

To sum up, the three variables in the electric transmission problem are :

1. the admission of the fuel which controls the engine torque;

2. the speed of the engine-generator group;

3. the excitation of the generator.

The heat engine itself imposes some restriction on the first two of these variables. Thus speed cannot be less than a certain limiting value or the engine will not run properly or be stalled, nor above a certain rate without undue wear. Moreover for each degree of admission of the fuel, the total efficiency of the engine depends on the speed and generally has a maximum value at a certain speed which again depends on the degree of admission considered.

To be suitable, any electrical transmission must satisfy as far as possible the following conditions :

1. The heat engine must work normally and its speed remain greater than that at which misfires or stalling of the engine may occur, whatever the tractive effort within optimum adhesion conditions, of course, at the tread.

2. For each degree of admission, the engine must run at a speed close to that at which the overall efficiency is best.

3. For all degrees of admission, and for all values of the tractive effort at the wheel tread, the engine must run at a speed as near as possible that which enables it to develop its maximum power.

4. The regulation of the speed and the tractive effort should be as easy and simple as possible, so far as the driver is concerned.

Principal electric transmissions.

Based on the speed of the set, these transmissions can be divided into two main classes :

1. those with which this speed is maintained constant by a centrifugal governor under all running conditions (tractive effort, speed) of the vehicle. In practice, so as to keep up the efficiency, there are a number of constant speeds corresponding to different admissions.

2. those with which the speed of the group is free to change with the characteristics of the electric circuit.

The above classification is rather theo-

retical as the most recent transmissions falling in the second class have been designed to pass through the critical speeds very rapidly. Some of the designers have even adopted a well defined series of speeds obtained by means of the Diesel engine governor.

1. *Systems with heat engine having one or several constant running speeds.*

This type of control corresponds either to the Ward-Léonard coupling, or to the use of an anti-compounding winding.

a) Ward-Léonard coupling.

In this system the main generator is excited separately by current usually supplied by an auxiliary generator. This excitation can be regulated manually or automatically by means of a rheostat.

The speed of the set being assumed to be constant, only the excitation and the fuel admission have to be acted upon so that at any moment the engine output is not less than the resistance to be overcome. This regulation can be left to the driver or be automatic by using a power relay, controlled by the current and voltage of the generator, which consequently controls the fuel admission to the Diesel engine.

This type of control and its modifications have been used very widely (Brown-Boveri, Compagnie Electro-Mécanique, Danish Trige Company, etc...).

In Denmark, in particular, the Diesel engines, besides the slow speed, have 2 or 3 constant running speeds and regulation is by varying the resistance in the separate exciting circuit. As the Diesel engine might be overloaded, a red lamp lights up, as a warning to the driver, as soon as the maximum admission is going to be exceeded. He should then move his governor handle back a notch, which slows down the vehicle slightly.

b) Use of an anti-compounding winding.

An anti-compounding winding on a generator makes self-regulation possible : when the main current increases the flux diminishes, and vice versa. The product of the amperes generated by the volts varies therefore but slightly and the Diesel engine can work at almost constant power. Actually the field of self-regulation is, with a simple system of this kind, too limited for traction requirements, and is only usable when the three methods of excitation (separate, shunt, and anti-compound) are combined, either in the generator itself, or in its exciter with additional resistances.

A system of this kind, which is known as the Lemp system (A.E.G.), has been developed in Germany.

The Thomson-Houston Company has built machines on the same principle in France.

c) Use of a compound dynamo and a motor-regulator (method patented by the A. S. E. A.).

2. *Systems with variable-speed heat engines.*

These systems can be used when there is no danger of critical speeds of rotation, or when special arrangements are used to run through them quickly. The following are the more important of such systems :

a) Use of an anti-compound generator with separate excitation.

This system is self-regulating but the full power of the Diesel engine cannot be made use of at all values of tractive effort and speed, if no resistance is inserted in the circuit. It is satisfactory for small powers.

b) Use of a shunt-wound generator.

The shunt-wound generator is also self-regulating, as for each degree of admission, the current and voltage of the generator vary inversely. This system has been developed by the Gebus Co., by the Oerlikon Co., etc.

c) Use of a generator with separate excitation by a small auxiliary generator on an axle of the vehicle and therefore having the same speed as the wheels.

This system is patented by Messrs « Les Forges et Ateliers de Constructions Electriques de Jeumont ».

d) System using a torque regulator.

The Westinghouse Company has invented a system based on the use of a regulator constantly altering the electrical circuit so that the torque of the engine always exceeds that of the generator. This is the « Torque System » widely used in the United States.

The different systems used on the most recent rail motor coaches will now be considered in somewhat greater detail.

Brown-Boveri electric drive.

General.

The Diesel engine is directly coupled to a main generator separately excited by an auxiliary exciter on the same shaft. The main generator supplies current to the traction motor or motors (Ward-Léonard coupling). A buffer battery across the terminals of the auxiliary generator supplies some of the current used by the auxiliaries. It is also used to start the engine, the main generator acting as the starter motor.

Regulating the Diesel engine output.

The Diesel engine in this case is run at constant speeds (2 or 3) which are as different as possible from the critical speeds.

These three speeds may be, for example, slow speed of about 500 r. p. m. and those of 1 100 and 1 400 r. p. m. This variation is obtained by altering the spring load of the centrifugal governor, and thereby the working regime.

For each working speed, the amount of fuel admitted can be altered to give four power outputs. As this variation is only economical between 55 and 100% of the maximum, the four rates of admission may be made to correspond, for example, to 55, 70, 85 and 100% of the maximum.

With the two speeds we get the following ranges of power relatively to the maximum power P_M :

at 1400 r. p m. :	P_M	0.85 P_M	0.70 P_M	0.55 P_M
at 1100 r. p. m. :	0.78 P_M	0.66 P_M	0.55 P_M	0.43 P_M

These two ranges overlap, and as slow speed working conserves the Diesel engine, the following may be taken as the working characteristics of this engine :

at 1100 r. p. m. : 0.43 P_M 0.55 P_M 0.66 P_M and 0 78 P_M
at 1400 r. p. m. : 0.85 P_M and P_M

Power regulation of the main generator.

As the generator must work at the above powers and speeds, we will now see how the factors — current and voltage — can be varied to comply with these conditions. We can do nothing as regards the current produced by the generator as it depends on the demands of the traction motors and is a measure of the tractive effort.

Consequently only the voltage can be altered. This depends on the speed of rotation (also fixed) and on the flux in the field windings, so that the latter is the only variable left over and the only one by which the excitation can be regulated.

This automatic regulation of the excitation to keep the product — field×current of the main generator — constant is obtained by the Brown-Boveri Company (B. B. C.) in two ways.

The exciter regulator is either operated electro-pneumatically, or is made to follow the movements of the Diesel engine governor sleeve by an oil-hydraulic servo-motor.

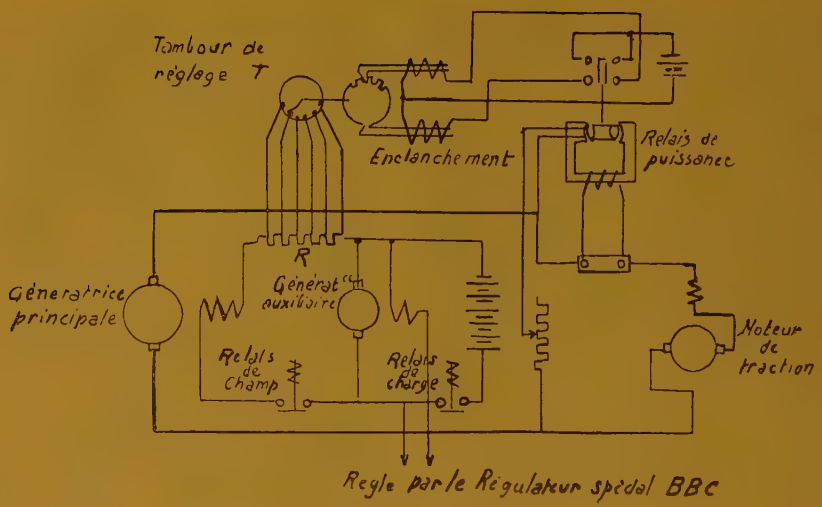


Fig. 37. — Layout of Brown-Boveri drive.

Explanation of French terms:

Tambour de réglage T = Regulating drum. — Enclanchement = Engaging relay. — Relais de puissance = Power relay. — Génératrice principale = Main generator. — Génératrice auxiliaire = Auxiliary generator. — Relais de champ = Field relay. — Relais de charge = Load relay. — Moteur de traction = Traction motor. — Réglé par le régulateur spécial BBC = Adjusted by special Brown-Boveri regulator.

The simplified diagram (fig. 37) does not show the connection between the characteristics of the Diesel engine (power and speed), and those of the excitation, but does indicate for a given Diesel engine output how the power of the generator can be kept constant.

It will be seen that the auxiliary generator produces across its terminals constant voltage by means of a special B.B.C. regulator acting on its own excitation.

The excitation of the main generator would be constant if the adjustable resistance B could be ignored.

This latter depends on the drum T, the operation of which is controlled by the power regulator, which in fact is simply a wattmetric relay, depending on the main current and the voltage. If therefore, for any Diesel engine output, that of the generator balances it and the traction motor current increases, the relay will insert a supplementary resistance in the excitation of the main generator, which will reduce the voltage, and the power output will finally be maintained constant.

With the B.B.C. transmission a Diesel engine having critical speeds can thus be used, as the usual operating speeds can be fixed in advance. The full power of the Diesel moreover can be used at all vehicle speeds. The equipment, when compared with simple governing, is rather complicated, but as the auxiliary generator operates at constant voltage it can supply current for lighting and for driving the compressor, etc... The system as a whole has advantages over others when provision has to be made for the additional equipment required on an important vehicle.

With the fully automatic B.B.C. system, the driver has only to control the Diesel engine.

When the excitation is controlled by hand, the driver has also to watch his Diesel speed indicator so as not to over-

load the engine. If this speed were exceeded the driver's attention could be called to it by luminous or audible signals when reaching maximum injection. The driver should then bring his lever back a notch to reduce the excitation and therefore the power output of the generator.

Amongt the vehicles which have been equipped with a B.B.C. transmission, the twenty 380-H.P. rail motor coaches delivered in 1932 and 1933 to the German State Railways should be mentioned. The Diesel engine used was made by MAYBACH and ran at the speeds mentioned above. The rail motor coaches in question weigh 42 tons and run at 110 km. (68.3 miles) an hour on the level.

A.S.E.A. transmission.

Old system.

The Swedish Company known as the A.S.E.A. (Allmänna Svenska Elektricität Aktiebolaget) originally used a transmission system incorporating a self-exciting shunt-wound dynamo like the Gebus.

This system was used on the 200-H.P. Burmeister and Wain Diesel-engined rail motor coach of the Belgian National Railways Company, put into service in February 1932.

The engine speed (850 r.p.m.) is maintained constant by a centrifugal governor acting on the fuel pumps.

The controller has two levers :

the reverse and coupling lever,
the regulating lever (15 notches).

This latter (notch 1) starts the Diesel engine by means of the battery and a series winding on the main generator. In notch 2, the battery current is cut off and the Diesel engine runs light.

Between notches 3 and 13 the voltage of the current fed to the traction motors increases progressively by cutting out resistances in the shunt exciting circuit. The last two positions (notches 14 and 15) correspond to the highest vehicle speeds when the traction motor field magnets are shunted.

The A.S.E.A. Company found this system required first of all a large number of notches on the controller and secondly a shunt dynamo which in theory can make it difficult to start. Then too the full acceleration the Diesel engine is capable of cannot be used to speed up the vehicle and this means some loss of time. On the other hand, the electric equipment is simple, as no exciter is needed for regulating purposes.

A.S.E.A. self-regulating system.

To obviate the above disadvantages the A.S.E.A. Company, in 1932, brought out an entirely automatic system which made it possible to make full use of the engine power over a wide range of vehicle speeds, and at the same time with the minimum number of notches.

This new equipment, used on the rail motor coach built by the « Aciéries du Nord » Company for the French Nord Railway, consists of the following main parts :

— compound excited dynamo directly coupled to the Diesel engine crank shaft;
— exciter, of appropriated design, coupled to the main generator shaft;
— traction motors, series excited;
— motor-regulator, of special design, giving completely automatic regulation.

This latter direct-current motor drives a fan on the shaft end which can be used for actually ventilating the motor or as a brake.

The connections used are shown on the diagram, figure 38.

Dynamo (1) has a field winding fed independently by the exciter (2) ; the motor-regulator (4) is coupled up in the exciter circuit and regulates the exciting current and thereby the main generator voltage.

The motor regulator has, on the one

hand, a field winding through which the main current to the traction motors passes and, in addition, a reserve action field winding $i_0 n_0$ supplied with constant-voltage current by the exciter. The exciting voltage, at a given Diesel engine speed, is constant. The exciter can thus be used for battery charging, lighting, etc.

Curve A, figure 39, shows diagrammatically how the equipment works. It shows how the dynamo exciting voltage should vary so that the power given by the Diesel engine remains constant.

To get this curve, the part B, corresponding to the voltage the motor regulator has to supply, must be deducted from the constant excitation voltage.

It will be noticed that this voltage, opposed to that of the motor-regulator, follows a normal magnetisation curve starting from the point 0.

The magnetisation curve is displaced in a parallel manner as far as the point 0 by the constant exciting current $i_0 n_0$.

The speed of the motor-regulator is practically constant within normal working limits.

This method of regulation is very simple. The motor-regulator can in some cases be used as a ventilating fan for the Diesel engine and then ceases to be additional equipment.

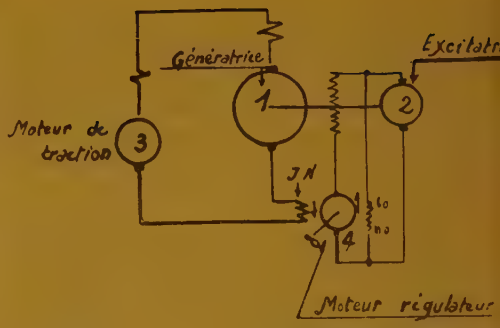


Fig. 38. — Layout of A.E.S.A. transmission.

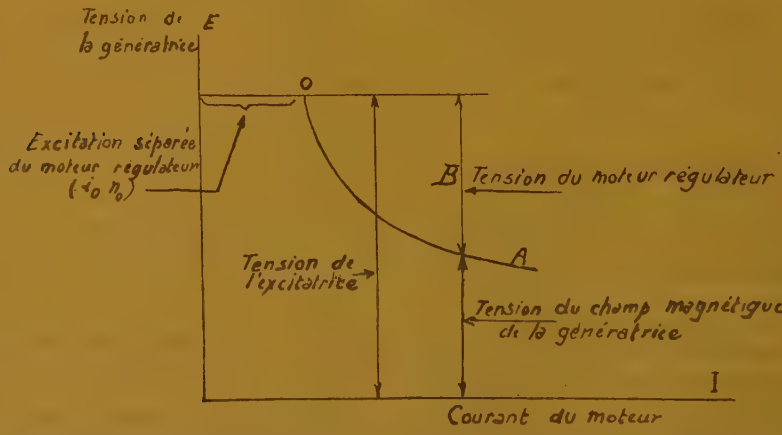


Fig. 39. — Calculation of the voltage of the A.S.E.A. motor-regulator.

Explanation of French terms:

Tension de la génératrice = Voltage of generator. — Excitation séparée... = Separate excitation of motor-regulator ($i_0 n_0$). — Tension du moteur régulateur = Voltage of motor-regulator. — Tension de l'excitatrice = Voltage of exciter. — Tension du champ... = Voltage of magnetic field of generator. — Courant du moteur = Current from motor.

Gebus electric transmission.

This system, it will be remembered, is based on the self-regulation qualities of the shunt-wound generator. In this case, the speed of the Diesel engine is not maintained constant by a centrifugal governor, for example, but is on the contrary variable and dependent on the voltage and current in the traction motor circuit, which in turn depends on the speed of the vehicle and the tractive effort developed. For a given admission, that is to say for a constant Diesel engine torque, the power is proportional to the speed of rotation. The generator giving an output represented by the product volts × amperes, these elements must vary in inverse ratio if the Diesel engine power output is to remain constant. The shunt-wound generator meets these requirements.

Thus, if under given running conditions, as regards vehicle speed and tractive effort, on the level, the tractive effort increases on running onto a gradient, the traction motors will require a higher voltage, and if the admission of the Diesel engine taken as working at its highest speed is not changed, the tension must fall sufficiently so that we can get a new balancing point at a slightly slower Diesel engine speed.

The relatively rapid fall of voltage for a slight variation in engine speed means that the generator is in the non-saturation zone of its characteristics, which lies in the rectilinear part and at the beginning of the bend of this curve.

From a designing point of view, this low saturation may be criticised as meaning a heavy cumbrous machine owing to the great weight of iron required and to the relatively large air gap needed. Part of this weight can, however, be made good by the reduction in the weight of copper due to the lower excitation required as compared with other systems.

Nonetheless, no simpler electrical system can be imagined as no resistance nor auxiliary excitation is needed, and the fuel pump is the only part to be regulated as it varies the output of the Diesel engine.

Moreover, at small admissions, with the Diesel engine running slowly, the shunt-wound generator may become dis-excited and the vehicle can be stopped without switching the traction motors off the generator circuit, which means a further simplification.

Against this, the vehicle may start badly owing to difficulty in energising the shunt generator. This draw-back can be overcome by a compound winding, which can be cut out after the vehicle has started (fig. 40 includes this winding).

a = *Main generator.*
b = *Traction motor.*

Fig. 40. — Simplified wiring diagram of Gebus system.

To facilitate starting, the characteristics of the traction motors can be specially studied in order to obtain, for slight voltage variations, relatively wide engine speed variations in the range of high current intensities. In other words, the curves of tractive efforts and motor speeds in the low voltage area should be as wide apart as possible.

This explains why the designer, by suitably controlling the generator as well as the traction motors, can produce a unit free from the minor difficulties mentioned above. The system will then be self-regulating and will have the sole drawback that the full engine power cannot be used at all speeds. Theoretic-

ally, it will be available at two speeds only, and these can be fixed in advance. There will be a slight falling off of power between them, not exceeding, however, 5 to 6%. The engine will be less subject to wear in this zone in which, if the maximum speed is limited to 1 400 r. p. m., the actual speed will be about 1330.

Finally, as the Diesel engine has to run at varying speeds, there should be no critical engine speed within its useful working range.

If this is not so, a Diesel engine governor must be fitted, which will run the engine through the critical speeds without the driver having to take action.

This, of course, is a precautionary measure for the Diesel engine and has nothing to do with the electrical transmission, which remains simple as before.

The GEBUS equipment is fitted on the

Fig. 41. — Driving cabin of « Schnelltriebwagen ».

German State Railways express rail motor coach (Schnelltriebwagen), of which figure 41 shows one of the driving cabins. However, on this coach the generator is only excited when the speed exceeds 750 r. p. m., and the Diesel engine governor spring is distant-operated to get either the first running speed of 1 100 r. p. m. or the speeds of from 1 200 to 1 400 r. p. m. by steps of 50 r. p. m. So that the two Diesel engines (one on each outer bogie) can be controlled simultaneously, a special control has had to be devised to provide this

simultaneous regulation. A second special generator has been used for the auxiliaries (lighting, battery charging, etc.).

As regards new constructions, the German State Railways seem to favour an electric transmission which at the same time is self-exciting with an anti-compound winding, and also has a separate exciter ; the latter is itself self-regulating thanks to two intensity relays inserted in the traction motor circuits.

The 40 motor coach sets (1934 type) of the Dutch State Railways, the twin-unit motor coach of the Belgian National Railways, built by La Brugeoise Company, and the two express three-body units of the French Nord Railway, are all fitted with a modified GEBUS transmission, in which resistances are inserted in the shunt exciting circuit of the generator at the same time as the Diesel engine governor is altered. The excitation of the generator is facilitated by a series field winding.

Oerlikon electrical transmission.

The Oerlikon Company supplied the Compagnie Française de Matériel de Chemins de fer, for a 130-H.P. rail motor coach for the Paris-Lyons & Mediterranean Railway, and for two bogie rail motor coaches, each bogie of which had a 140-H.P. engine, for the Franch Nord Railway, with a particularly simple equipment based on the use of shunt-excited generators coupled direct to each Diesel engine.

No special excitation nor regulating auxiliary is used; the battery is the only important accessory.

As stated by the OERLIKON Company, particular attention was paid, not so much to getting a rigorously constant output from the Diesel engine as to reducing the weight to the minimum, and to simplifying everything in order to get acceleration and overall speeds comparable with those given by more complicated equipment.

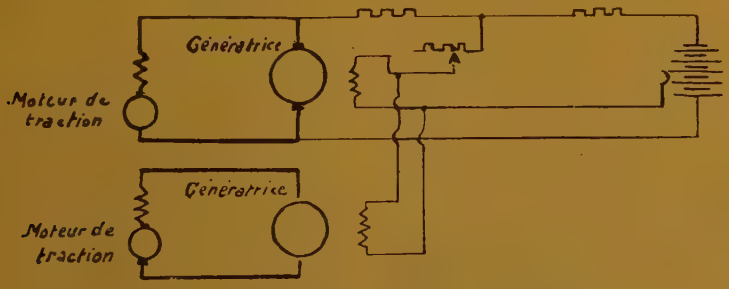


Fig. 42. — Diagram of OERLIKON transmission.

Figure 42 shows the principle of the transmission as fitted to the French Nord Company's rail motor coach. The transmission includes two generators shunt excited, two series traction motors, a battery of accumulators and an adjustable resistance.

The controller has two cylinders :

— the reverse,

— the control properly speaking with twelve notches.

These twelve notches are the following :

— 1 starting,
— 1 neutral,
— 3 notches in which the exciting current il taken from the battery,
— 7 self-exciting notches.

Thus the difficulties in starting a shunt generator are overcome by means of the battery. When running as a self-exciting machine, the main generator supplies current for recharging the battery.

The electric transmission of the Forges et Ateliers de Constructions Electriques de Jeumont.

In this design, the field windings of the generator G are fed by an exciter E running at a speed proportional to that of the traction motor M to which it is coupled mechanically. This exciter E is itself excited by a storage battery the current of which can be controlled by a rheostat *Ra*.

It will be seen that when about to start, and the traction motor has not yet begun to revolve, if the generator has no residual excitation, the exciter cannot supply exciting current, as it is not in motion ; the generator cannot produce any current and the vehicle cannot be started.

To overcome this, a battery can be inserted in the generator exciting circuit, to provide a certain amount of excitation even when the exciter is not revolving. This battery can, moreover, be inserted in the traction motor circuit so as to be recharged automatically whilst the railcar is running, by current from the generator.

If this system were discussed in detail, the value of a voltage regulator (potentiometer) on the battery so as to get the best start without stalling the engine, would be appreciated. Besides, the battery can be replaced by a small ohmic resistance. The generator, at starting, would then be excited as though it were a series generator with the field magnets shunted by this resistance.

Once the vehicle has started, the working is controlled by the fuel admission valve and the exciting rheostat of the exciter.

In all cases, the intensity of the exciting current and the speed of the rail motor coach vary automatically inversely for any given power corresponding to a given fuel admission, and for any given resistance of the exciter rheostat; the speed of the heat engine also varies but not below a certain rate depending on the setting of the excitation regulating resistance and, of course, the admission of fuel.

The advantage of this system is that the full engine power is used for wide variations in the working conditions of the motor coach.

The heat engine can also be run in the most economical way for each degree of admission, as the speed of the engine can always be brought to its optimum value by the field regulating resistance.

This system is an example of what can be done to get the best operating conditions, as regards both power and fuel economy. Il is only obtained at the price of some complication, and batteries are necessary.

An example of a rail motor coach designed on the above principles is the one supplied to the French Nord Railway by the Aciéries du Nord Company, with a 200-H.P. Diesel engine and two traction motors. It is a 2-B_0 type coach.

Besides the equipment theoretically necessary, this rail motor coach has an auxiliary generator K, driven by the Diesel engine, which charges the batteries and also supplies current for one of the methods of exciting the axle-driven exciter which has a shunt winding and a special winding.

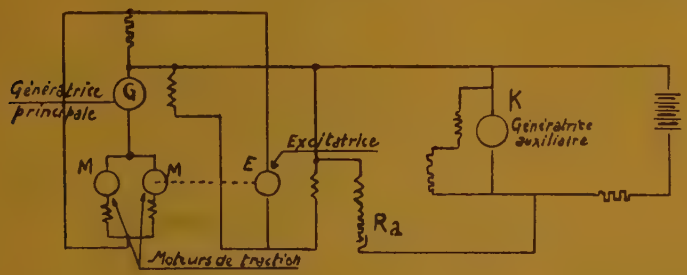
The Diesel engine is controlled by electro-pneumatic valves whereby its speed can be limited. One of these valves is operated by the starter and corresponds to the slow running speed of the engine. The three others are part of the controller and correspond : the first two to constant speeds of 650 and 850 r.p.m., and the third to variable speeds between 900 and 1 200 r.p.m.

The theory we have developed above applies to this zone of speeds of the internal combustion engine, as there is no fear of critical speeds being set up in this zone.

This zone corresponds to seven notches on the controller, that is to say seven adjustments of the power obtained by varying the excitation of the auxiliary generator and the separate excitation of the axle-driven exciter.

As regards using the power of the Diesel engine in terms of the vehicle speed, the attached diagram (fig. 43) shows that, as soon as the speed reaches about 20 km. (12.4 miles) an hour, the full power of the engine is always available.

Layout of JEUMONT *transmission. Aciéries du Nord railcar.*



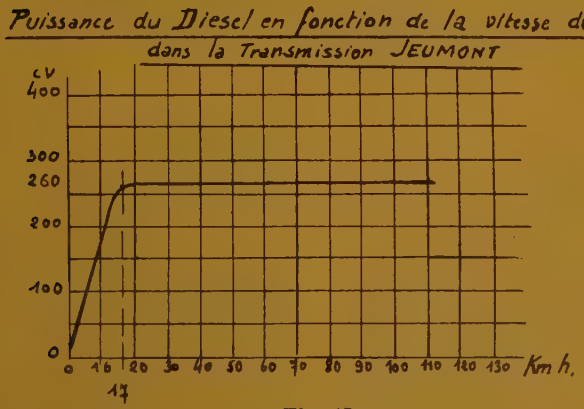


Fig. 43.

Note: Puissance du Diesel... = Power curve of Diesel engine in terms of the vehicle speed, with the Jeumont transmission.

CHAPTER V.

Hydraulic transmissions.

With hydraulic transmission the torque and speed of the secondary shaft can be varied continuously whatever the engine speed may be. It is based on the principle of the hydraulic turbine.

It consists of a torque converter and a coupling.

The *torque converter* consists of a centrifugal pump on the engine shaft and a hydraulic turbine, the moving vanes

of which are secured to the secondary shaft whilst the fixed vanes form part of the casing.

The pump on the engine shaft acts as the generator and forces the oil through the turbine which functions as a receiver and drives the secondary shaft.

The coupling enables the engine shaft to be coupled to the secondary shaft in order to give direct drive, and is either hydraulic or mechanical.

The VOITH and LYSHOLM-SMITH hydraulic gears are described below.

Voith hydraulic transmission.

In the Voith transmission the same casing contains two distinct units : a torque converter A and a coupler B (fig. 44).

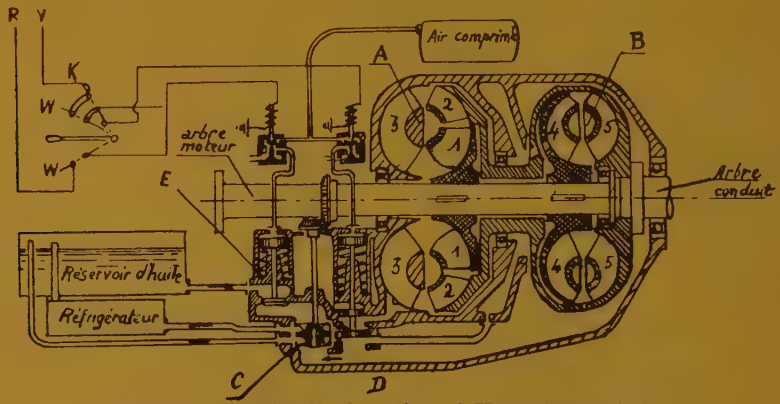


Fig. 44. — Longitudinal section of VOITH transmission.

Explanation of French terms:

Air comprimé = Compressed air. — Arbre moteur = Main shaft. — Arbre conduit = Driven shaft. — Réservoir d'huile = Oil tank. — Réfrigérateur = Cooler.

The converter A is made up of three parts :

— a centrifugal pump (1) keyed on the primary or engine shaft ;

— a hydraulic turbine rotor (2) keyed on the secondary or driven shaft ;

— a distributor or hydraulic turbine stator (3) the vanes of which are fastened to the casing.

The coupler B is a Föttinger hydraulic clutch and is formed of two symmetrical half tores, one (4) keyed to the engine shaft, and the other (5) fastened to the driven shaft.

A rotary pump C driven by the engine shaft recovers any leakage liquid and drives the oil through a cooler. By means of an electro-pneumatically controlled distributor valve, the oil can be sent either to the torque converter A, or to the coupler B. The passage from one to the other is practically instantaneous, and when this is taking place, it is not necessary to cut off the carburetter in the case of a petrol engine, or to reduce the injection on an oil engine. Finally by means of a flap valve, also electro-pneumatically operated, the fluid can be completely prevented from entering the transmission, and coasting is obtained without any ratchet device.

A 200-H.P. Voith transmission weighs 1 000 kgr. (2 200 lb.) including the fluid, when the main shaft runs at 1 400 r.p.m., and only 400 kgr. (880 lb.) [fluid and multiplying gear included] when the

primary shaft absorbs the same power of 200-H.P. at 2 900 r.p.m.

In order to save weight, the transmission for the German State Railways' motor coaches with 600-H.P. Maybach engines includes a multiplying gear combined with the reverse gear.

With the electro-pneumatic control of the distribution valve, which sends the oil to the converter or to the coupler, distant control of several sets of gears may readily be used.

The Voith transmission has been in use for over a year on a number of Austro-Daimler rail motor coaches fitted with petrol engines giving 80 to 90 H.P. at 3 000 r.p.m.

Some of these railcars are working under exceedingly difficult conditions on lines with heavy gradients, such as the Semmering line.

Three 160-200 H.P. sets of transmission gear have been delivered to the builders of rail motor coaches for the German State Railways, but the coaches are not yet delivered.

Two 420-450 H.P. and seven 280-300 H.P. sets are being built at Heidenheim, also for the German State Railways, and two 105-H.P. sets for a Dietrich railcar for the French railways.

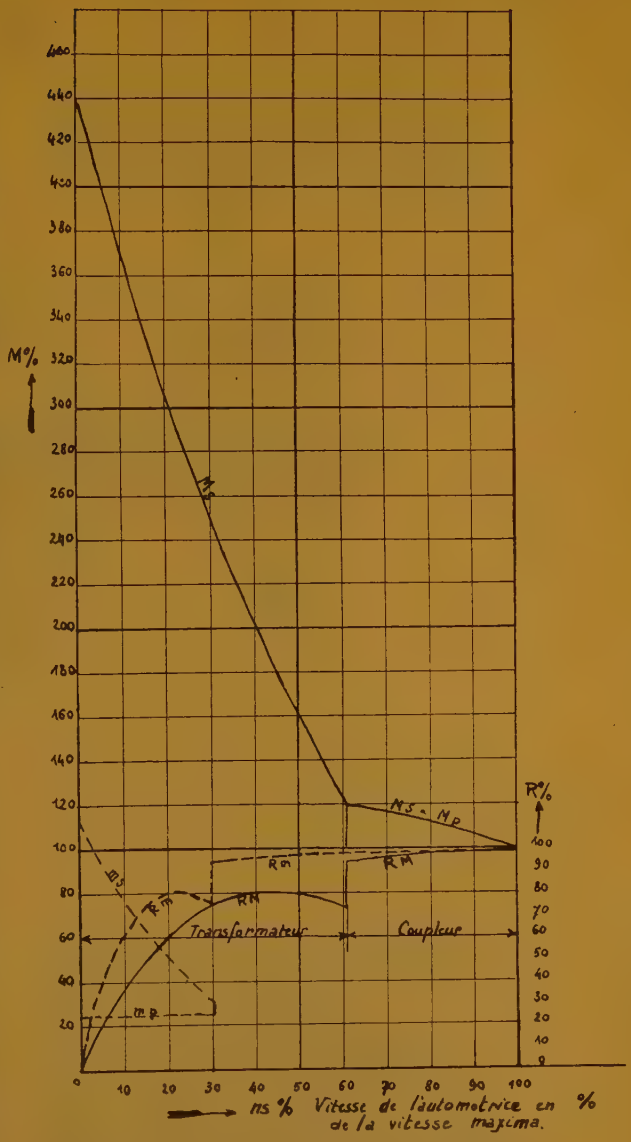
Finally, designs for four sets to work with the supercharged 600-H.P. Maybach engines for the German State Railways are in hand.

Lysholm-Smith hydraulic transmission.

This transmission is composed of a centrifugal pump the rotor B of which is secured to a sleeve B which carries a clutch plate A (fig. 46).

A turbine rotor D, with three rings of vanes free to turn, is connected to the secondary shaft S through a free wheel F. Two fixed rings H, solid with the outer casing, complete the turbine.

The transmission includes two clutch plates, one of which, A, is fastened to the pump rotor, and the other, K, to the



Efficiency of VOITH transmission without multiplying gear ————.

Efficiency of VOITH transmission with multiplying gear - - - - - - - - -.

Fig. 45. — VOITH transmission. Driving torque and efficiency in terms of the engine speed.

Note: Transformateur = Torque converter. — Coupleur = Coupler. — Vitesse de l'automotrice... = Speed of railcar, per cent of the maximum speed.

secondary shaft. A single lever is used to take the drive through either plate K or A. When A is thrown in, the pump and the turbine come into action. If however K is driving, the pump is no longer driven, and the turbine itself remains stationary as, thanks to the free wheel F, the secondary shaft is directly driven without the turbine rotor being driven at the same time.

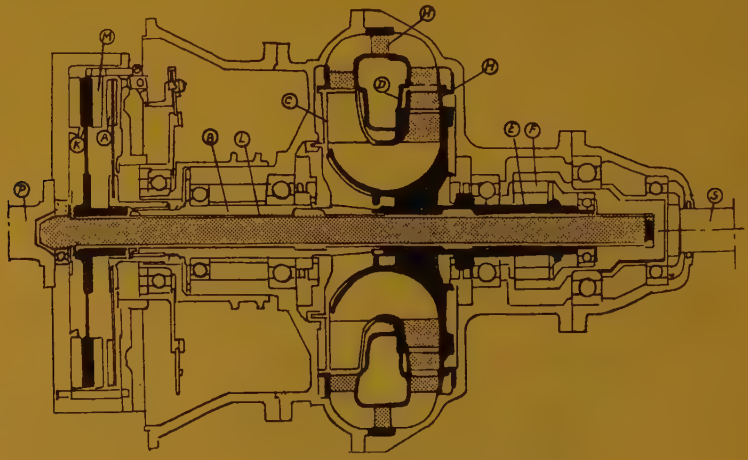


Fig. 46. — Lysholm-Smith transmission.

This transmission gear is used on some rail motor coaches on the London Midland and Scottish Railway.

* * *

CHAPTER VI.

The running gear and bogies of rail motor coaches.

A. — *Wheels.*

The wheels may be grouped into two classes :

1. Elastic wheels subdivided into those with :

A) elastic rims;
B) rigid metal rims.

2. Rigid all-metal wheels.

1. A) *Wheels with elastic rims.*

The most widely used is the Michelin wheel used on French rail motor coaches.

The main features may be recalled briefly.

These wheels are fitted with a pneumatic tyre adapted for running on rails (fig. 47).

The detachable wheel is made of pressed discs of the road motor car type. The rim is extended on the inside by a flange in steel plate stiffened by corrugations. Its diameter is greater than that of the pneumatic tyre, and it is fitted with a steel ring which acts as the flange, and it is deadened by inserting a rubber ring.

The pneumatic tyre is kept on the rim by an easily removed ring.

The tread is grooved to improve the adhesion.

A safety device is fitted inside the

tyre and consists of a rigid ring of suitable section intended to prevent anything serious happening if the tyre becomes deflated or burst, by reducing the amount the wheel can drop to 1 cm. (3/8 inch.).

The tyre pressure is about 7 kgr./cm² (100 lb. per sq. inch.).

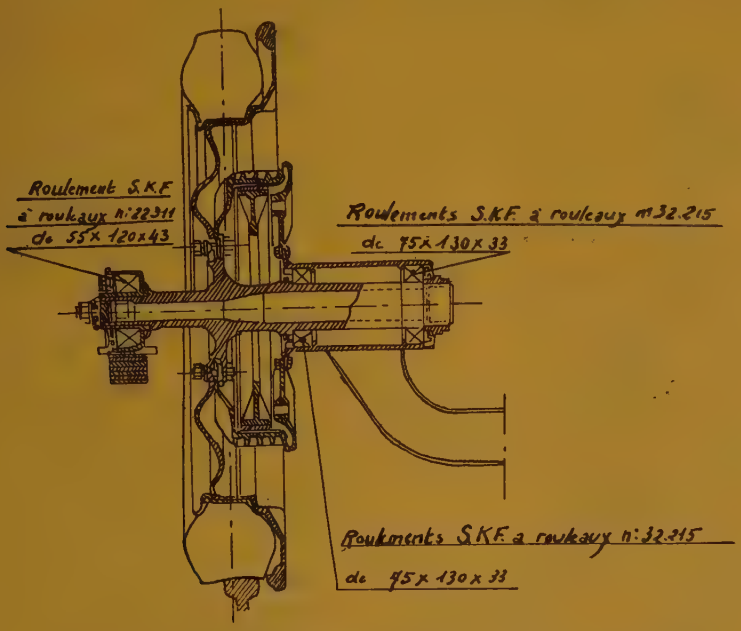

Roulement S.K.F
à roulaux n°22311
de 55 x 120 x 43
Roulements S.K.F. à rouleaux n°32.215
de 75 x 130 x 33
Roulements S.K.F. à roulaux n°32.315
de 75 x 130 x 33

Fig. 47. — Carrying axle and wheel of 36-seater MICHELINE.

Note: Roulements... = S.K.F. roller bearings.

The advantages of the Michelin wheel are well known :

— protection of the vehicle against shocks and vibrations, so that light construction is possible;

— absence of noise from tyres rolling on the rails;

— much greater adhesion between wheel and rail than with steel wheels.

It must be noted, however, that owing to the narrow bearing surface (4 to 5 cm. = 1 3/4 to 2 inches) the wheel load is limited. Moreover the use of pneumatic tyres between the mass of the vehicle and the files of insulated rails, together with the low weight on the wheels, have made it necessary to design special devices for short-circuiting the track. Finally, the use of the Michelines also makes it necessary to alter somewhat the design of detonators.

B) *Elastic wheels with rigid metal rims.*

The feature of these wheels is the interposition of some elastic medium between the wheel centre and the tyre.

Two classes of wheels are to be considered :

— those with a ring or band of rubber providing *radial elastic connection and at the same time lateral elastic connection* between the rim and the wheel centre;

— those in which these two require-

ments are met by *separate* elastic devices, one to give *radial* and the other *lateral* flexibility.

The first group includes the elastic wheel reported by the Bergslagen Rail-

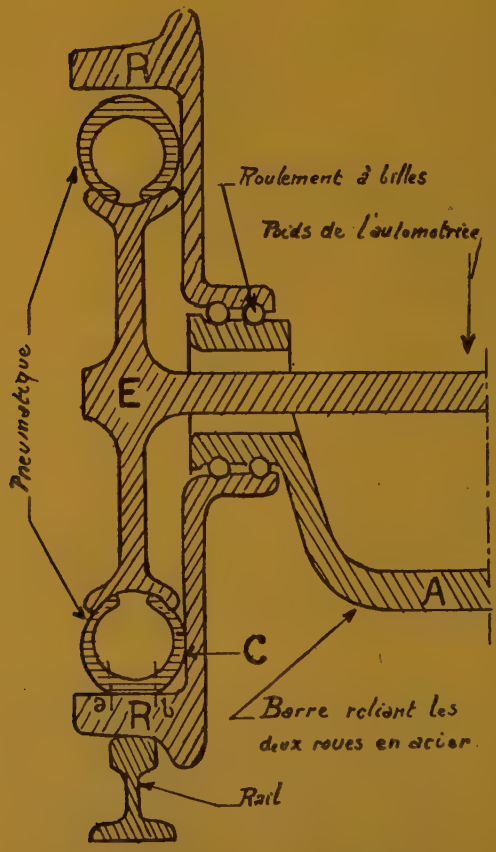


Fig. 48. — DAIMLER wheel.

Explanation of French terms:

Roulement à billes = Ball bearing. — Poids de l'automotrice = Weight of railcar. — Pneumatique = Pneumatic tyre. — Barre reliant... = Bar connecting the two steel wheels.

way (Sweden), which wheel has two rubber rings between the tyre and the wheel centre. The tyre and centre are held together by bolts and a steel retaining ring.

The wheel used by the Austro-Daimler Company, which deserves a special description, can be included in the same group.

This wheel has a pneumatic tyre inside a steel drum fastened to a rigid metal wheel with a tyre and flange (fig. 48).

The two steel wheels of a set are carried and connected together by a crank axle which keeps them the correct distance apart.

The vehicle is supported on these wheels through a straight carrying axle and wheels with pneumatic tyres.

The result is that vertical thrusts and side shocks exerted by the track on the steel tyre are damped out by the pneumatic tyre.

The pressure in the pneumatic tyres is 2.5 to 3 kgr./cm² (35.5 to 42.7 lb. per sq. inch).

From a practical point of view, the Austro-Daimler wheel has the following features :

— the pneumatic tyre has a large bearing surface and can be loaded up to 3 000 kgr. (6 600 lb.) per wheel ;

— the wear of the pneumatic tyre is reduced through running on a perfectly smooth surface ;

— the cost of two concentric axles is comparatively high.

The second class of wheels includes the following :

L. B. (Bacqueyrisse) wheel
(fig. 49)

This wheel, which is used on the de Dietrich rail motor coaches, has a rubber ring A compressed between the centre and the tyre. Its function is to damp out radial shocks Two other rubber rings C are held in place on the sides of the wheel centre by manganese silicon steel plates, and provide a lateral elastic connection.

The three rings A and C all play their part in providing the necessary connection between the tyre and centre in

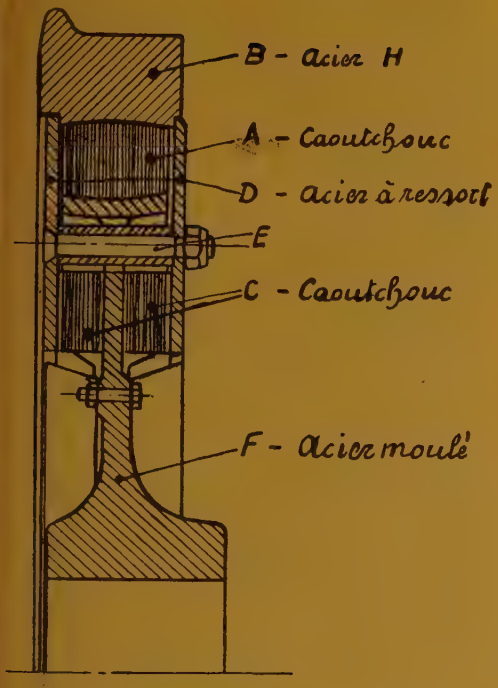


Fig. 49. — Elastic wheel, L. B. system.

Explanation of French terms:
Acier = Steel. — Caoutchouc = Rubber. — Acier à ressort = Spring steel. — Acier moulé = Cast steel.

order to deal with the tangential forces due to the tractive effort and to braking.

Bugatti wheel.

Three rubber bands, tightly pressed against one another, are inserted between the tyre and the wheel centre to damp out vertical vibrations.

The tyre is bolted to the centre by bolts with rubber ferrules to damp out the vibrations that might be set up in driving the wheel.

Rubber rings are used to damp out the lateral shocks.

S. O. M. U. A. wheel

The tyre is connected to the wheel centre disc by pins working in silent-blocks.

Indiarubber washers are fitted on the silent-blocks between the collar of the tyre and the discs and provide lateral elasticity.

Elastic wheels have the advantage of damping out, at least partly, the vibrations and shocks experienced in running and therefore help to give greater comfort. They have the disadvantage of greater weight and cost, and involve special equipment for short-circuiting track-circuited rails.

2. *All-metal rigid wheels. — One-piece wheels.* — The one-piece wheels are cast or forged steel wheels, usually with thin tyres.

The one-piece wheels under certain RENAULT rail motor coaches are fitted with an anti-noise ring of rubber, bolted to the centre, intended to damp out the vibration of the wheel itself

Wheels with tyres. — Most of these are of the classic railway type with lightened tyres secured by Gibson rings to cast or forged steel centres.

The diameter on the tread is usually 850 to 970 mm. (2 ft. 9 1/2 in. to 3 ft. 2 1/4 in.). Diameters less than the U. I. C. sizes are in use, however. The Bugatti wheel is only 710 mm. (2 ft. 4 in.), and the Breda 700 mm. (2 ft. 3 1/2 in.). The Belgian National Railways Company has adopted the diameter of. 970 mm. (3 ft. 2 1/4 in.) for rail motor coaches.

The tyres are usually thinner than the usual 75-mm. (2 61/64 inches) used on carriages and wagons. The Belgian National Railways Company uses 50-mm. (1 31/32 inches) tyres on its rail motor coaches, the same thickness as is used on the « Schnelltriebwagen ». The de Dietrich rail motor coach which is fitted with brake drums and the tyres of which consequently wear very little, have been made only 40 mm. (1 37/64 inches) thick.

A reduction of 25 mm. (63/64 inch) in thickness means a saving of some 600 kgr. (1 320 lb.) in the case of a bogie rail motor coach.

One-piece steel wheels are of forged tyre steel or special steel, such as nickel-chrome-molybdenum, for example.

In wheels with tyres, cast or forged-steel centres are used, sometimes made of special nickel-chrome steel, and the tyres are of carbon steel of the usual tyre steel quality.

Flange lubricators to reduce flange wear on curves are far from being generally used.

B. — *Axle boxes.*

Roller bearing axle boxes are generally used for both driving and carrying axles.

Two types are in use :

— road motor car type or special boxes ;

— railway boxes like those used under carriages.

The first group includes the BUGATTI box for fixed axles, and the SOMUA box used on the Paris-Lyons & Mediterranean's four-wheeled rail motor coach.

The second group covers the boxes of most bogie rail motor coaches.

It should be noted that the Isothermos box is used on a number of such coaches.

C. — *Axles.*

The axles are either the road motor car type with wheels running freely on fixed axles and the driving wheels keyed or shrunk on the axle or driving shaft, or, more generally, the railway type with the wheels pressed on hot.

The motor car type axles are generally in use on light four-wheeled rail motor coaches. The driving axle then follows the design of a motor car back axle, but without differential. Examples are : the BUGATTI loose wheel, the driving axle of the SOMUA for four-wheeled coaches, the loose and driving wheels on the BERGSLAGEN Railway (Sweden), and the driving axle on the DECAUVILLE bogie axles on the Dutch rail motor coach sets.

Most heavy bogie rail motor coaches have railway type axles of reduced section, thanks to the use of special steels such as nickel-chrome.

Hollow axles are sometimes used, as for example the DE DIETRICH driving axle in nickel-chrome steel, and the axles on the Dutch rail motor coach sets.

The body of the SOMUA rail motor coaches is carried on four laminated springs supported by the frame through shackles. The wheels are guided by these springs, no axle guards being used. Silent-blocks are used throughout the spring gear. Shock absorbers between the frame and axles damp out the oscillations.

Most rail motor coaches are, however, fitted with axle guards to guide the axles, the boxes sliding in the guards being given suitable lateral and longitudinal play. Long laminated carrying springs are used.

The rail motor coach built by LES ENTREPRISES INDUSTRIELLES CHARENTAISES is unusual in that the body is carried on four pairs of wheels and not on bogies. The wheels are connected in pairs by equalizers carried on the roller bearing axle boxes. The outer axles are given some play to facilitate running through curves.

The rail motor coach built by the COMPAGNIE GÉNÉRALE DE CONSTRUCTION also has some peculiar features. The body is carried on the two pairs of wheels through laminated springs 2 m. (6 ft. 6 3/4 in.) long. The boxes are carried on two bissel trucks which enable the axles to adapt themselves to the track. The side play, limited by stops, is 33 mm. (1 19/64 inches) each side. Adjustable stops are provided for limiting this play in the case of the leading axle.

D. — *Rail motor coach bogies.*

Conditions to be fulfilled by rail motor coach bogies :

1. — *The bogie considered as the connection between the wheels and the body.*

From this aspect the coach can be dealt with as a carriage or wagon being hauled. It must be remembered that, in most cases, other than multiple units or those able to haul a trailer, the rail motor coach is operated as a separate unit.

The points to be examined are :

a) guiding the axles relatively to the bogie frame ;

b) suspension of the bogie frame on the wheels ;

c) suspension of the body relatively to the bogie frame ;

d) part played by the pivot, carrying the body or merely moving it ;

e) side friction blocks, carrying the whole weight of one end of the body or only part, or balancing the body.

The object to be realised is that of the coach builder :

A) not to transmit to the body, or at least to damp out, the longitudinal and transverse shocks due to entering curves and to irregularities in the track ;

B) to avoid hunting.

2. *The bogie considered as a motor part driving the coach.*

The bogie has to be designed to meet its functions as either a driving or simply a carrying bogie relatively to the rail motor coach.

Different designs, briefly reviewed below, have been introduced to suit the type of engine and its position on the vehicle, and the type of transmission.

a) *Diesel- or petrol-engined rail motor coaches with mechanical or hydraulic drive.*

The bogie can be :

— a driving bogie, carrying an engine driving one or two pairs of wheels (many Belgian, German, French, Hungarian, etc. rail motor coaches) ;

— a driving bogie the axles of which are driven by an engine carried on the body (Bugatti, Renault, etc.) ;

— a carrying bogie.

b) *Diesel- or petrol-engined rail motor coaches with electric transmission.*

The bogie can be :

— a power bogie carrying the Diesel engine and the electric generator (the majority of rail motor coaches with electric transmission in most countries) ;

— a power and driving bogie at once, i.e. carrying the Diesel engine, generator, and traction motors (new Swedish A. S. E. A., and Compagnie Française de Matériel de Chemin de fer, rail motor coaches) ;

— a driving bogie carrying the electric traction motors only, the Diesel engine being in the body (Dutch sets) or on the other bogie ;

— carrying bogie.

c) *Steam rail motor coaches.*

— driving power bogie carrying the boiler, steam engine, and transmission by gearing or jack shaft and connecting rods (Birmingham Railway Carriage & Wagon Co.'s rail motor coach, in service in Belgium) ;

— driving bogie driven by the steam engine carried under the frame (Sentinel rail motor coaches in Belgium and England) ;

— carrying bogie.

3. *The bogie considered as carrying the brake equipment.*

In designing, and especially in building bogies, the brake gives rise to several problems. On rail motor coaches the brake must be powerful and reliable. Ample power must be provided to operate brake blocks or bands, which must be applied rapidly.

The brake gear must be compact, simple, light, and strong, with few articulations, so as to reduce play. The design should be such that it can be fitted without difficulty to driving or power bogies, whereon much space is already taken up by the engine and mechanism.

Most builders consequently fit the whole of the brake equipment, including cylinders and auxiliary reservoirs, on the bogie itself. In some instances the cylinders are solid with the bogie frame itself.

Classification by design of bogie.

The bogies examined can be grouped into three classes :

1. *Bogies of types generally used under carriages and wagons :*

A. Wagons-lits (sleeping-car) type,

B. Pennsylvania type,

C. Goerlitz type,

D. With single spring gear.

2. *Bogies of the type used on electric locomotives.*

These are bogies carrying the electric traction motors of rail motor coaches with electric transmission (Belgian A. S. E. A. rail motor coach, for example).

3. *Special type bogies* (Bugatti or Michelin bogie, for example).

We will consider more particularly the bogies of the first class, as the other type are very particular and have been dealt with in the technical press.

A) *Wagons-lits type bogies.*

Particular examples of the use of this bogie are :

— Bogies used on the Finnish State Railways and on the rail motor coach built by the Compagnie Française de Matériel de Chemins de fer for the French Nord Railway.

Finnish Stade Railways' bogies.

These bogies come under the classification : driving bogies carrying electric traction motors. They are four-wheeled, with 2.40 m. (7 ft. 10 15/32 in.) wheel base. The pivot is central.

The bolster beam is carried from the bogie frame by inside swing links with knife edges.

The bogies are built of plates and rolled sections rivetted together.

Compagnie française bogies.

These bogies carry a Diesel engine, a generator, and an electric motor driving one of the axles.

The cast steel one-piece frame (fig. 50) is carried on the boxes by laminated springs and rubber shock absorbers.

The body is connected to the frame through a bolster with two groups of elliptical springs between the body bolster and the bogie bolster.

The body is carried on the body bolster by a centre pin and spherical seating, and friction blocks without any spring centering device.

The bogie bolster is of the usual design with the bolster carried by short links with round pins. In addition to the elliptical springs mentioned above, a large rubber pad is fitted under the centre to which it is bolted, the bolts being fitted with rubber ferrules.

B) *Pennsylvania type bogies.*

The carrying bogies on many rail motor coaches belong to this type.

Bogies of the Dutch three-coach sets (fig. 51)

The Dutch three-coach set has four bogies :

2 outer four-wheeled carrying bogies and two intermediate six-wheeled driving bogies. Figure 54 shows one of the driving bogies.

A carrying bogie weighs 4 900 kgr. (10 800 lb.) ;

Fig. 50. — One-piece cast steel bogie of the Compagnie Française railcar.

A driving bogie weighs 7 580 kgr. (16 710 lb.), not including the two traction motors, the weight of which is 3 100 kgr. (6 830 lb.).

Bogies of the C. K. D. & Skoda railcars of the Czechoslovakian State Railways (fig. 52).

The carrying and driving bogies of these coaches are of the Pennsylvania type.

The bogie bolster has a play of 1 mm. (0.039 inch) longitudinally, and 23 mm. (0.905 inch) side play on each side of the centre.

Figure 52 shows a driving bogie of the Ceskomoravska-Kolben-Danek rail motor coaches.

Renault bogies.

The middle carrying bogie of Messrs. Renault's twin rail motor coaches is a 3-m. (9 ft. 10 1/8 in.) wheel base bogie of the Pennsylvania type.

C) *Goerlitz type bogies.*

The bogies under many rail motor coaches in most counstries come under this heading. The Goerlitz bogie is actually an excellent design when Diesel engines and transmission gear, whatever the type, have to be fitted between its two sole bars.

Bogies of the « Schnelltriebwagen ».

This twin rail motor coach is carried on three bogies, the two outer being

Fig. 51. — Driving bogie of Dutch three-car set.

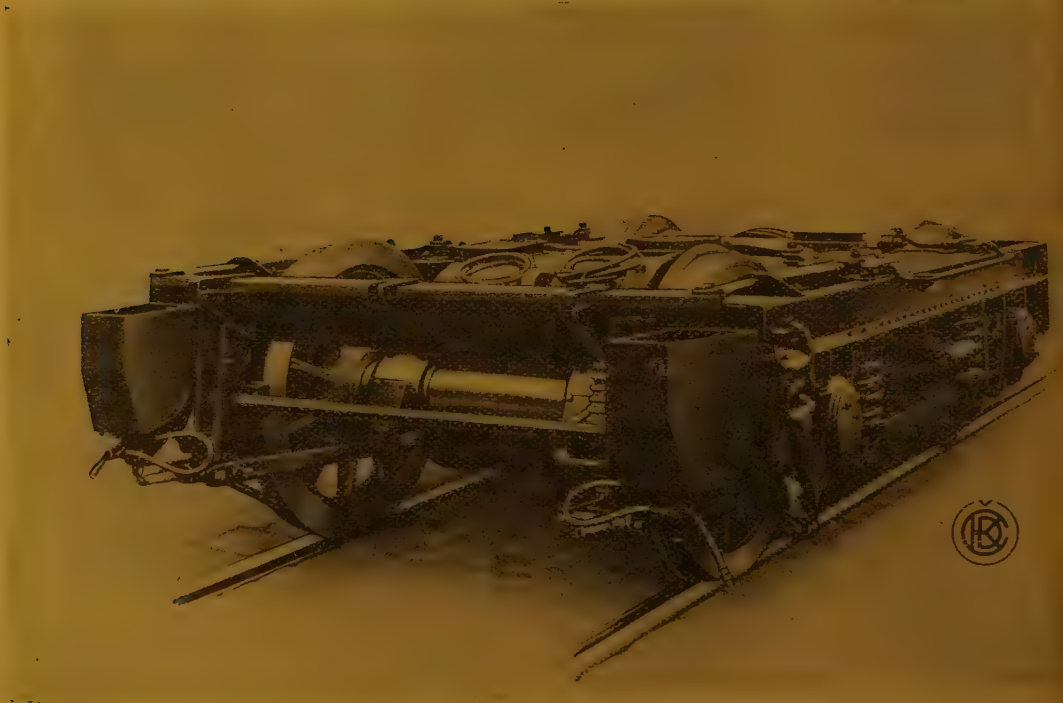


Fig. 52. — Driving bogie of C.K.D. railcars, Czechoslovakian State Railways.

power bogies, the middle one being the only driving one, with each axle driven by an electric traction motor.

The bogie frame is built up of plates and rolled sections welded together, and is carried on four laminated springs with square section steel auxiliary coiled springs.

The body is carried on a bolster over the frame in the case of the power bogie. The ends of this bolster are carried on two longitudinal springs attached to the frame by adjustable shackles.

This rail motor coach is braked in rather a special way. The Knorr automatic air brake is used. A brake cylinder is fitted for each brake shoe, to which it applies the effort through a short lever. These shoes, two per wheel, brake the outside of the cast steel brake drums bolted to the wheel centres.

The outer power bogie by itself (without Diesel engine and generator) weighs 7 155 kgr. (15 770 lb.), and 13 t. (12.8 Engl. tons) in running order.

The centre bogie by itself weighs 7 630 kgr. (16 820 lb.) and 13.6 tonnes (13.4 Engl. tons) in running order.

Bogies of the de Dietrich rail motor coach.

The two identical bogies (fig. 53) fall into the group of driving bogies carrying the Diesel engine which drives one axle directly.

Fig. 53. — Bogie of DE DIETRICH railcar.

These bogies are of the usual design although the laminated bearing springs are carried under the axle boxes.

Houdaye shock absorbers are provided between the bogies and the body in order to damp out the hunting movements of the coach. It weighs 5 800 kgr. (12 780 lb.).

Fig. 54. — Driving bogie of BRNO-KRALOVOPOLSKA railcars, Czechoslovakian State Railways.

Fig. 55. — Bogie of the ACIÉRIES DU NORD railcar, French Nord Railway.

Bogies of the Brno-Kralovopolska railcars of the Czechoslovakian State Rys.

The driving bogie of these coaches is of the usual type ; it is shown in figure 54. It carries the 8-cylinder V-fashion Diesel engine, the electric generator and the traction motor.

Aciéries du Nord bogies.

This firm built for the French Nord and State Railways rail motor coach bogies of the Goerlitz type, but with appreciable differences.

Those of the Nord (fig. 55) have a bolster, the others (State) have none, but instead have long longitudinal laminated springs on which the body is suspended relatively to the bogie frame.

In the case of the Nord rail motor coaches, the frame is carried on the axle boxes by coiled springs of rectangular section, shock absorbers being fitted between the boxes and the frame.

The bogie bolster is connected to the frame by four longitudinal laminated springs with coiled auxiliary springs. In addition, a rubber block is fitted under the centre to damp out vibration.

The body rests on the spherical centre carried by the bolster, and the usual friction blocks are provided.

The bogie weighs 7 525 kgr. (16 590 lb.).

On the French State Railways motor coaches, the frame is carried by laminated bearing springs.

The body is carried on longitudinal laminated springs fastened to the frame.

An extension of the spring buckle has spherical bearing surfaces carrying a body friction block.

The body bolster carries a pin, held at both ends, about which a spherical bearing, fastened to a body bolster, can rock (sphere in nitrided steel).

Bogies of the Frichs railcars.

Figure 56 shows the 6-wheeled driving bogie of the latest 440-H.P. railcars introduced in 1934 on the Danish State Railways. This bogie carries two 220-H.P. engines placed side by side, with their generator on their main shaft.

The power set is raised so as to be on the same level as the floor, in order to facilitate inspection of the engines and generators.

Driving bogies of the Maybach 175-H.P. Diesel rail motor coaches of the Belgian National Railways Company.

These bogies (fig. 57) may be considered as falling into the Goerlitz group. The frame is carried on laminated springs. The body is carried by the frame through longitudinal laminated springs with the ends attached to the frame and not to the bogie frame as before.

The buckles of these springs are fitted with slippers working on slides on the bogie frames.

The body bolster carries a pin held fast at its lower end about which a spherical bearing rocks (like the one described above).

The way the wheels are driven by a jack shaft, rods and crank should be noted.

D) *Bogies with single spring gear.*

These bogies are not fitted with bolsters nor with any secondary suspension.

The bogie frame is carried by four laminated springs resting on the boxes or bolted under them.

The body is carried on a centre and side friction blocks. The latter are fitted with springs to balance the body.

Fiat bogies.

One of these bogies (fig. 58) is a driving bogie carrying a petrol engine driving one axle. The other is simply a carrying bogie.

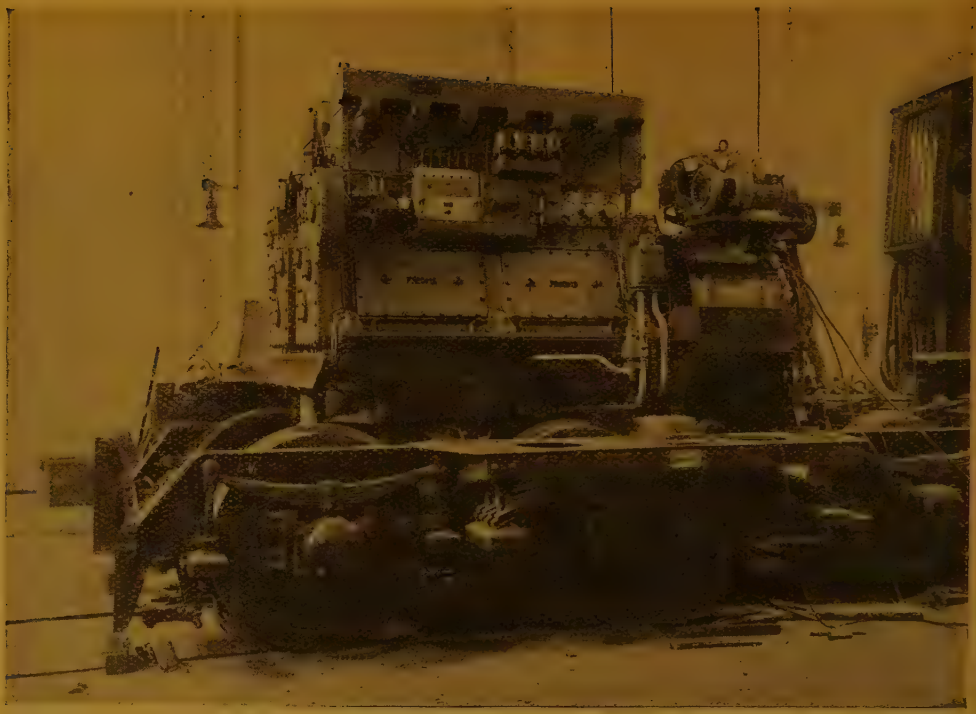


Fig. 56. — Six-wheeled bogie of the latest 440-H.P. railcars of the Danish State Railways.

Fig. 57. — Bogie of the 175-H.P. MAYBACH railcars.

Fig. 58. — FIAT bogie.

The bogie frame is suspended on four laminated springs with helical-spring shock absorbers of a special design.

The body is carried on the bogie by a centre with roller side bearings.

The wheel base is 2.80 m. (9 ft. 2 1/4 in.) to 3 m. (9 ft. 10 1/8 in.) according to type.

The bogie centre pin is not central.

Breda bogies.

The driving bogie is carried on the roller bearing axle boxes by four independent laminated springs with auxiliary rubber springs.

The carrying bogie is fitted with four helical bearing springs on the boxes.

The wheel base is 2.80 m. (9 ft. 2 1/4 in.).

The bogie centre pin is out of centre. It is located 1.64 m. (5 ft. 4 1/2 in.) from one of the axles.

The bogie is connected to the body through the centre and side friction blocks.

Renault bogies.

The bogie is carried on the boxes by reverse-camber laminated springs with auxiliary springs consisting of piled-up rubber rings.

Rubber rings are inserted between the spring buckles and the axle boxes.

The body is carried on a centre with a large block of rubber between the centre and the bogie, and has 25 to 30 mm. (1 in. to 1 3/16 in.) play on each side of the centre line. This centre is braked by two shock absorbers.

The side checks are elastic; a spring holds a shoe lined with ferodo against a friction block on the bogie frame.

These side checks help to balance the body and reduce hunting of the bogie.

Decauville bogies.

The Decauville bogie carries the Diesel engine which drives the two axles through worm gear.

These axles are in fact arranged like a motor car rear axle but without differential.

The body is carried on the two axles by four laminated springs with some reverse camber, secured under these axles.

The spring brackets are fitted with silent-blocks.

Radius thrust rods to take the torque and brake reactions connect these axles to the bogie sole bars.

This arrangement has been considered adequate for guiding the axles correctly in relation to the frame. Axle guards are not fitted.

The body rests on a spherical centre attached through rubber springs to a cross shaft connected by inclined links to the bogie frame and free to move transversely.

The link joints are fitted with silent-blocks.

The total weight of the motor bogie in working order is 7 000 kgr. (15 430 lb.).

Hungarian Railways bogies.

The bogie frame rests on groups of helical springs carried on two levers fastened under the boxes.

The body is carried on the frame by a centre and side bearings.

Rubber shock absorbers are fitted over the helical springs, under the spherical centre, and under the side bearings.

To damp the oscillations of the helical springs, the axle boxes and guards have been given large guiding surfaces.

* * *

Generally speaking, the bolster type bogie is preferred by many companies both as driving and as carrying bogies. It was the only one used on rail motor coaches in the beginning, but some builders, looking for lightness and simplicity, have given it up. Single suspension bogies are used nearly always on vehicles worked without trailers and therefore not subject to any reaction at their ends, and give satisfactory results.

The usual wheel base is 2.50 to 3.50 m. (8 ft. 2 7/16 in. to 11 ft. 5 25/32 in). The driving bogies carrying the Diesel engine have necessarily a longer wheel base than that of the carrying bogies (in practice 2.70 to 3.50 m. [8 ft. 10 5/16 in. to 11 ft. 5 25/32 in.]).

The centre in the case of driving bogies is always eccentric by about 0.40 m. (15 3/4 inches). The maximum reported is 0.90 m. (2 ft. 11 1/2 in.) on the Decauville bogie.

Bogie bolsters are usually given side play which may be over 20 mm. (25/32 inch) on each side of the centre line. There is no proof that this side movement is necessary. Many builders consider it harmful, whilst others recommend it, and provide damping devices to control it. When the bogie has no bolster, there is no lateral displacement of the centres, except in the case of the Renault and Decauville bogies.

Bogies without bolsters are fitted with elastic side bearings to balance the body, whereas when bolsters are fitted, ordinary side bearings are fitted and the play between friction plates, allowed by the builders, varies from 1.5 to 5 mm. (0.056 to 0.197 inch.).

Rubber is widely used to reduce noise and damp out vibrations. It is used : as auxiliary bearing springs, pads being placed under the bearing spring buckles, the bogie centres, and the side bearing blocks; in the form of silent-blocks for articulated joints. Some companies, however, consider that indiarubber, far from damping out the vibrations, sets up resonance at certain times, which passengers find unpleasant.

It would, therefore, be premature to decide in favour of any particular type of bogie. The Companies should carry out systematic trials on a given rail motor coach in order to ascertain the favourable or unfavourable influence of the different factors.

CHAPTER VII.

Rail motor coach brakes.

The braking of rail motor coaches is a problem of some complexity, as these vehicles are used and operated under very special conditions. The rail motor coach represents both automobile and railway practice, and this explains why the brakes used may be of the :

— automobile type,
— railway type, or
— combined type, partly automobile, partly railway.

Some designers have even adapted to rail motor coaches the brakes used on aircraft (Charlestop brake, for example).

Rail motor coaches being intended to run alone, without a trailer, or with special trailers, their brakes need not be designed to work in conjunction with other brakes and for braking long rakes of stock. This explains why the choice of the brake is much less limited than in the case of ordinary railway vehicles and it is the reason for the diversity of the designs in use on rail motor coaches.

A rail motor coach is generally fitted with a service brake, an emergency brake, and a standby brake. This is not an absolute rule, as if a service brake is naturally always fitted, this is not so with the other two. In certain cases the service brake can take the place of the other two. The most general arrangement of these three classes of quite distinct brakes will be considered in turn.

1. *Service brake.*

Rail motor coach service brakes are almost always compressed air brakes, which differ by :

— the way the compressed air acts ;
— the nature of the friction surfaces between which the braking action occurs, and finally
— the way the initial braking effort is transmitted to the friction surfaces.

a) Action of the compressed air.

The initial braking effort is produced by admitting compressed air into one or several brake cylinders, in one of the two following manners :

1. directly, that is to say without using a distributor with the *direct brake;*

2. through a distributor, which admits air from an auxiliary reservoir in each vehicle, into the brake cylinders, in the case of the *automatic brake.*

b) Nature of friction surfaces.

From this point of view there are two quite distinct classes of brake. Those with which the friction is :

1. between cast iron blocks carried on the frame and the steel tyres of the wheels. This is the *standard railway method ;*

2. between drums fastened to the wheels and articulated grippers or segments lined with woven or moulded asbestos carried on a plate fastened to the axle casing or the oil box. This is the *standard automobile method.*

c) Transmission of the braking effort.

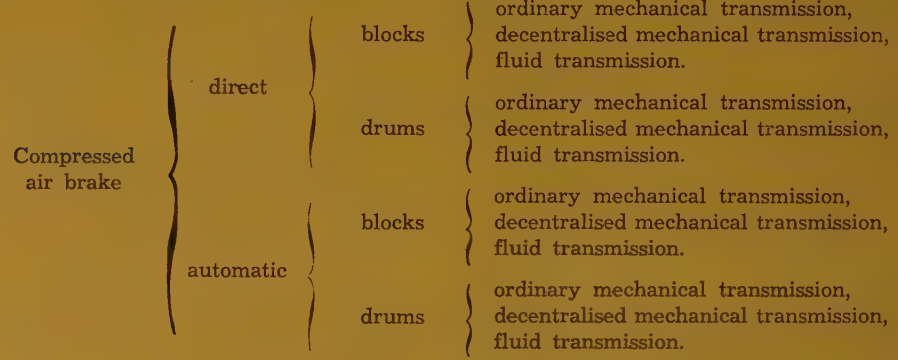
The initial braking effort is transmitted in one of the following principal ways :

1. ordinary mechanical transmission by brake gear of the railway type or cables ;

2. decentralised mechanical transmission, that is to say using a number of cylinders acting directly upon each brake shoe or segment ;

3. fluid transmission on the following principle : The compressed air piston operates a pump which compresses a fluid. By means of suitable flexible piping, the fluid under pressure is admitted into small cylinders operating directly and individually the brake blocks or segments (Lockheed brake, for example).

To sum up, and as a result of the variations of the above mentioned characteristics, the different service brakes used on rail motor coaches may be classified as follows :



Each of the brakes represented above can be controlled in several ways : by a driver's valve, or by a reaction brake foot pedal so arranged that the driver can feel the braking effort exerted, or by lever.

* * *

Theoretically, braking on a drum seems to be the better method, and many European railways have adopted it for their rail motor coaches. It is particularly advantageous when the automatic brake is used, that is to say when the highest possible pressure has to be exerted in the air cylinder.

Let $Q =$ the constant maximum pressure between the friction surfaces,
$F =$ coefficient of friction between these surfaces,
$P =$ weight of the braked vehicle,
$\Phi =$ coefficient of adhesion between the wheel and the rail.

Then, if skidding is to be avoided :

$$QF \leqslant P\Phi \text{ or } Q \leqslant P\frac{F}{\Phi}.$$

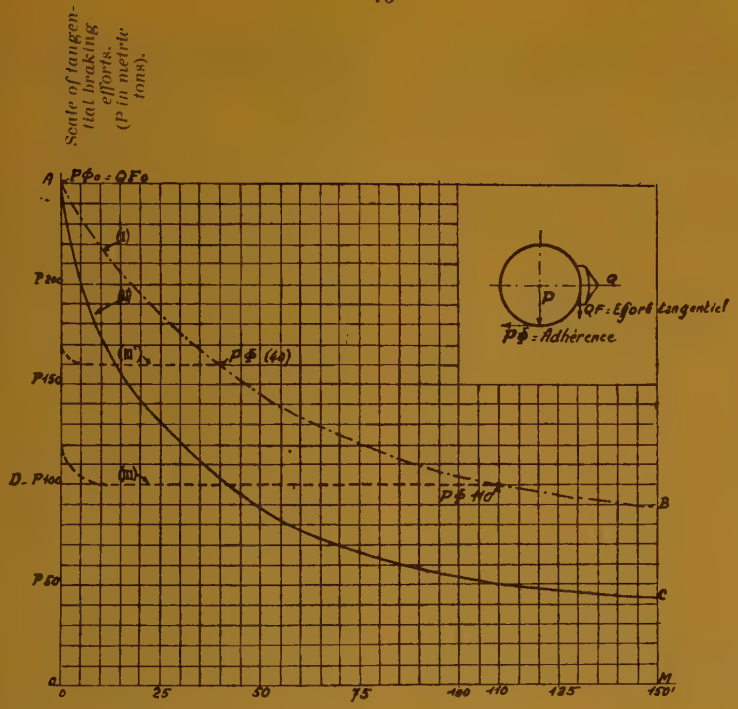
Now, when brake blocks are used, the coefficient of friction between the block and the tyre increases considerably as the speed of the braked vehicle falls, and as this increase is much greater than the simultaneous value of the coefficient of adhesion, the result is that QF increases much more quickly than $P\Phi$, as shown by figure 59, given by Mr. Bordes at a lecture before the Société des Ingénieurs Civils, Paris.

Consequently, the more the speed of the braked vehicle falls the greater the tendency to skid. To prevent this, Q must be given such a value that this skidding cannot occur except on coming to rest. This means that :

$$QF_0 = P\Phi_0 \qquad Q = P\frac{\Phi_0}{F_0}.$$

The pressure Q so obtained is much lower than the pressure that can be used without any danger of skidding at the maximum speed of the vehicle. At high speeds, the braking is therefore much less than the maximum possible, and this prevents us from getting the shortest possible stopping distances.

When the brake acts on a drum, the coefficient of friction between the brake lining and the drum is almost constant at all speeds. The factor $P\Phi$ therefore grows whilst QF remains practically



(I) P Φ (v) = Adhesion.
(II) Q F (v) = Braking effort of shoe brake.
(III) = Braking effort of drum brake for V = 100 km. (68.3 miles) per hour.
(III') = Braking effort of drum brake for V = 40 km. (25 miles) per hour.
Note: Effort tangentiel = Tangential effort. — Adhérence = Adhesion.

Fig. 59.

constant (see figure 59) so that there is no fear of skidding at slow speeds. Q can therefore be given the value that will ensure maximum braking at the highest possible vehicle speeds. If the maximum speed be V, Q can consequently be given such a value that

$$QF_{(V)} = P\Phi_V \qquad Q = P\,\frac{\Phi_V}{F_V}.$$

Figure 59 shows three retardation curves : with brake blocks, with the brake drum when V = 40, and when V = 110. If we compare these curves we see that, when first applied, the drum type brake is the better, and the brake block only has the advantage below a certain speed given by the intersection of the retardation curves. It will appear *a priori* that a brake should give the greatest retardation at high speeds, and both calculation and practice show that the final advantage is with the drum type brake, both as regards the stopping distance and time. At present, their use is rather limited to the direct brake, brake blocks being used with the automatic brake as a rule. However, some Administrations, among them the Alsace-Lorraine, are already using the automatic brake in conjuction with drums, and others, such as the Hungarian Railways, are considering its use on their new rail motor coaches.

Messrs. Jourdain-Monneret have perfected an arrangement which, in con-

junction with brake blocks, proportions the braking effort to the speed of the rail motor coach. This device makes use of centrifugal force to increase the braking effort at high speeds ; it has been fitted to the « Franco-Belge » rail motor coaches of the French Nord Railway. As regards the method of transmitting the initial braking effort, fluid transmission is the most usual, at least when brake drums are used. A few isolated applications are even found on railcars fitted with the automatic shoe brake, as for example the « Franco-Belge » rail motor coach mentioned above.

Finally, the usual method of control is by a driver's valve in the case of the automatic brake, and a pedal when the direct brake is used.

If theoretically the brake drum is definitely to be preferred, practically speaking it still has the following drawbacks: It takes much room, whether the drums are placed between the wheels and soles, as the linings are awkward to renew, and it is very difficult to replace the drums, or when they are outside the wheels, the wheels having then to be of large diameter for the drums to come within the loading gauge.

The linings wear rapidly if they are not made of ample size in proportion to the actual weight of the rail motor coach. Many coaches weigh more than the calculated weight, so that the drums designed on the latter weight are frequently too small. Finally, if the distant control of the drum brake gets out of adjustment, there is danger of the wheels being skidded *at high speeds* (and not at slow, as when brake blocks are fitted). A coach which picks up its wheels at high speeds is much more dangerous than one which skids at slow speeds, because it would strike any obstacle with its full momentum. Furthermore, special precautions have to be taken to see that the sanding is instantaneous and operates before the brake acts so that the coefficient of adhesion is a maximum when there is danger of skidding.

II. *Emergency brake.*

An emergency brake distinct from the service brake is not fitted on all rail motor coaches. In many instances, the service brake is used for emergency applications. Such application can be made by the driver, by the usual application device, or by the guard or passengers, by an alarm device, when the service brake is automatic.

The electro-magnetic rail brake is much used in France and Germany as a special emergency brake. The magnetic shoes of this brake are energised by passing an electric current through them when applying the brake and this brings them in contact with the rails. It has the pecularity of being independent of the adhesion and can therefore give high retardation. It is therefore remarkable as an emergency brake and is the only one used on rail motor coaches. Unfortunately, after an emergency application, it leaves small blue marks on the rails through local heating, which the permanent way engineers of various railways are investigating.

III. *Standby brake.*

The standby brake is usually the hand brake, screw or lever operated, acting directly on the rigging of the service brake when fitted, or is quite independent when no such brake is fitted.

When the service brake is automatic, the standby brake is frequently a compressed air direct-acting brake which duplicates the former.

Some rail motor coaches are not fitted with any standby brake. In this case the service brake is divided into sections, each acting on some of the braked wheels only, with independent control.

* * *

We saw that, when the compressed-air direct action brake is fitted, the air is admitted to the brake cylinder directly without passing through a distributor. The driver himself regulates the quantity of air admitted into the cylinder and thereby varies the braking power as he wishes. He can as a rule apply the brake hard enough to pick up the wheels, this action varying with the speed.

When the automatic brake is fitted, the maximum pressure which can be obtained in the brake cylinder is constant, and is fixed. The maximum braking is therefore also constant and independent of the speed, and this is a valuable characteristic of the rail motor coach, known as the braking coefficient.

In the case of brakes with blocks, this coefficient is the ratio of the actual pressure on the blocks to the total weight of the vehicle. In Central Europe, it is usually 80 to 85 % of the tare, and 65 to 70 % of the loaded weight. In France it is generally much higher and is 100 to 115 % of the tare and 75 to 80 % of the loaded weight.

We can give no precise data on the brakes using brake drums, as these have been used almost solely with the direct acting brake up to the present.

* * *

CHAPTER VIII.

Rail motor coaches in the various countries.

Germany.

On the 1st January 1934, the German State Railways had 102 rail motor coaches in service, and 98 under trial or under construction.

The 98 rail motor coaches under trial or construction included 90 rail motor coaches with Diesel engines, 5 with steam, and 3 with petrol engines ; 51 of them had mechanical transmission, 43 electrical transmission, and 4 hydraulic transmission gear.

All these rail motor coaches can reverse and have two driving compartments.

Most of the rail motor coaches under trial or construction are bogie vehicles.

It would seem that the stock of the future will consist of rail motor coaches and trailers on bogies of a standard type, the trailers having a driving compartment for use when the direction of running is reversed. Such rail motor coaches will be equipped with Diesel engines of about 400 H.P.

The German State Railways, under the technical direction of Dr. Fuchs, and with the assistance of the builders, are at the present time carrying out very interesting trials on the three following points :

1. Use of Voith hydraulic transmission for powers up to 400 H.P.

2. Use of condensed steam on rail motor coaches, Doble system, designed by Messrs. Borsig and Messrs. Henschel.

3. Increase of the power of Diesel engines by the use of supercharging (Maybach).

Four-wheeled rail motor coach with 120-H.P. Daimler engine.
(10 vehicles in service, 10 under trial or construction).

1 Daimler 120-H.P. Diesel engine, 1 700 r.p.m., in the middle of the vehicle, under the floor.

T.A.G. mechanical transmission, constant-mesh gear box. Four speeds, 40 seats. Weight, 14.5 t. (14.3 Engl. tons).

Maximum speed : 72 km. (44.7 miles) an hour.

Fig. 60. — 12-wheeled « Schnelltriebwagen » (Twin rail motor coach for express trains).

*Eight-wheeled rail motor coach with 380-*H.P. *Maybach Diesel engine*

(3 vehicles in service, 24 under trial or construction).

380-H.P. Maybach Diesel engine, 1 350 r.p.m.

Electrical transmissions of various designs. 72 seats. Weight, 41 t. (40.4 Engl. tons).

Maximum speed : 110 km. (68.3 miles) an hour.

*Eight-wheeled rail motor coach with 175-*H.P. *Maybach Diesel engine.*

(17 vehicles in service).

175-H.P. Maybach Diesel engine, 1 400 r.p.m.

Maybach mechanical transmission, constant-mesh gear box with four speeds.

2 driving axles driven by jack shaft and connecting rods.

71 seats. Weight, 41 t. (40.4 Engl. tons).

Maximum speed : 65 km. (40.4 miles) an hour.

« *Schnelltriebwagen* » *(Express railcar) with 6 pairs of wheels.*

(One vehicle in service) (fig. 60).

Two 380-H.P. Maybach Diesel engines, 1 350 r.p.m.

Body composed of 2 units on three bogies.

Gebus electrical transmission.

Each end bogie carries a Diesel engine and a generator ; the middle bogie carries the traction motors.

102 seats. Weight, 74 t. (72.8 Engl. tons).

Maximum speed : 160 km. (100 miles) an hour.

Figure 41 shows the driver's stand of the « Schnelltriebwagen ».

300-H.P *steam rail motor coach.*

(3 vehicles under construction) (fig. 61).

2 Doble boilers with instantaneous vaporisation and automatic regulating.

Steam pressure : 130 kgr./cm. (1 840 lb. per sq. inch.).

2 steam engines on the same bogie.

60 seats. Weight : 34 t. (33.5 Engl. tons).

Maximum speed : 90 km. (56 miles) an hour.

A similar rail motor coach has just been put into service between Hamburg and Lubeck.

Fig. 61. — DOBLE steam rail motor coach.

GERMANY

Transmission.		Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
Type.	Builders.								
In service.									
12 petrol railcars of various designs, 75 to 100 H.P.									
ech.	Various.	50-65 (*31-40.4*)	4	20 (*19.7*)	Rev. Trailer.	45	1926-1927	4 500-6 900 (*2 800-4 300*) in Sept. 1933.	Local trains.
4 Deutsche Werke railcars with one Deutsche Werke 150-H.P. petrol engine.									
ech.	T.A.G.	60 (*37.3*)	8	36 (*35.4*)	Rev. Trailer.	70	1926	6 139 (*3 815*) in Sept. 1933.	Local.

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order. t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
13 railcars of various designs, with two 90-H.P. engines.									
Mech.	Various.	60-70 *(37.3-43.5)*	8	37 to 41 *(36.4 to 40.4)*	Rev. Trailer.	56 to 81	1926-1927	6 500-8 000 *(4 040-5 000)* in Sept. 1933.	Local.
3 Wumag railcars with 1 Maybach 100-H.P. petrol engine.									
Mech.	Mylius.	65 *(40.4)*	4	13 *(12.8)*	Rev. Trailer.	43	1932	4 277 *(2 657)* in Sept. 1933.	Local.
3 railcars with one 120-H.P. Vomag C.E.H. petrol engine.									
Mech.	T.A.G.	65 *(40.4)*	4	13.7 *(13.5)*	Rev. Trailer.	46	1932	7 414 *(4 607)* in Sept. 1933.	Local.
1 Deutsche Werke railcar with one 150-H.P. Deutsche Werke petrol engine.									
Mech.	Deutsche Werke.	60 *(37.3)*	8	21.8 *(21.5)*	Rev. Trailer.	50	1933	5 387 *(3 347)* in Sept. 1933.	Local.
4 Waggonfabrik Wegmann railcars with one 75-H.P. M.A.N. Diesel engine.									
Mech.	Zahnrad-fabrik.	70 *(43.5)*	4	21 *(20.7)*	Rev. Trailer.	46	1927	...	Local.
*4 Waggonfabrik Wegmann railcars with two 75-H.P. M.A.N. Diesel engines.**									
Mech.	Zahnrad-fabrik.	70 *(43.5)*	8	39.5 *(38.9)*	Rev. Trailer.	83	1928	...	Local.
17 Waggonfabrik Wismar railcars, with one 175-H.P. Maybach Diesel engine.									
Mech.	Maybach.	65 *(40.4)*	8	41.0 *(40.4)*	Rev. Trailer.	71	1926-27-28	6 000 *(3 730)* in Sept. 1933.	Local.
2 railcars with one 120-H.P. Daimler Diesel engine.									
Electr.	Gebus-Siemens.	65 *(40.4)*	4	15.5 *(15.3)*	Rev. Trailer.	43	1932	...	Local.
10 railcars with one 120-H.P. Daimler Diesel engine.									
Mech.	T.A.G.	72 *(44.7)*	4	14.5 *(14.3)*	Rev. Trailer.	40	1933	...	Local.
3 Waggonfabrik railcars with one 380-H.P. Maybach Diesel engine.									
Electr.	Maffei-Schwartz-kopf Werke.	110 *(68.3)*	8	52 *(51.2)*	Rev. Twins. Trailer.	72	1933	...	Express.
25 Wumag railcars with one 175-H.P. Maybach Diesel engine.									
Mech.	Maybach.	80 *(50)*	8	29.5 *(29)*	Rev. Trailer.	63	1933	8 698 *(5 404)* in Sept. 1933.	Fast local

* *Note.* — Railcars marked * have been described in the text.

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service
*1 Wumag railcar (Schnelltriebwagen) with two 380-H.P. Maybach Diesel engines.**									
lectr.	Gebus-Siemens.	160 *(100)*	12	74.4 *(73.2)*	Rev. Twins. No trail.	102	1933	15 500 *(9 630)* in Sept. 1933.	Express.
Under trial or construction.									
28 railcars with one 150-H.P. M.A.N. Diesel engine.									
electr.	Brown-Boveri.								
mech.	T.A.G. or Mylius.	70 *(43.5)*	4	16.5 *(16.2)*	Rev. Trailer.	40 to 45	...	...	...
hydr.	Trilok.								
hydr.	Voith.								
*10 L.H.B. railcars with one 120-H.P. Daimler Diesel engine.**									
lech.	T.A.G.	72 *(44.7)*	4	14.5 *(14.3)*	Rev. Trailer.	40	...	...	...
3 L.H.B. railcars with one 100-H.P. Henschel petrol engine.									
lech.	Zahnrad-fabrik.	60 *(37.3)*	4	12 *(11.8)*	Rev. Trailer.	46	...	...	...
*19 Wismar railcars with one 380-H.P. Maybach Diesel engine.**									
lectr.	S.S.W. A.E.G. B.B.C.	110 *(68.3)*	8	41 *(40.4)*	Rev. Twins. Trailer.	72	...	...	...
5 M.A.N. railcars with one 380-H.P. Maybach Diesel engine.									
lectr.	Brown Boveri Co. (B.B.C.)	110 *(68.3)*	8	41 *(40.4)*	Rev. Twins. Trailer.	61	...	...	...
6 L.H.B. railcars with one 300-H.P. Motoren Werke or Daimler Benz Diesel engine.									
lectr.	A.E.G.	90 *(56)*	8	42.2 *(41.5)*	Rev. Twins. Trailer.	66	...	...	...
19 Wumag railcars with one 210-H.P. Maybach Diesel engine.									
lech.	Maybach.	80 *(50)*	8	29.5 *(29)*	Rev. Trailer.	63	...	...	...
1 M.A.N. railcar with one 420-H.P. Diesel M.A.N. engine.									
lectr.	B.B.C.	110 *(68.3)*	8	...	Rev. Twins. Trailer.	61	...	...	...

Note. — Railcars marked * have been described in the text.

Transmission.		Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order. t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
Type.	Builders.								
2 Waggonfabrik Wismar railcars with one 600-H.P. Mayback Diesel engine.									
Electr.	B.B.C.	130 *(80.8)*	8	...	Rev. Twins. Trailer.	...	...	...	...
2 Wegmann railcars with one 100-H.P. Doble Borsig steam engine.									
...	...	65 *(40.4)*	4	14.5 *(14.3)*	Rev. Trailer.	42	...	...	...
*3 Wegmann railcars with two 150-H.P. Doble Borsig steam engines.**									
...	...	90 *(56)*	8	34 *(33.5)*	Rev. Twins. Trailer.	60	...	...	...

* *Note.* — Railcars marked * have been described in the text.

Austria.

The Austrian Federal Railways at the present time have 48 rail motor coaches in service :

— 26 with petrol engines, 22 with Diesel engines;

— 18 with mechanical transmission, 24 with electrical transmission and six with hydraulic transmission.

They have under construction four rail motor coaches with two 80-H.P. petrol engines, and hydraulic transmission.

« Maschinen u. Waggonbaufabrik A. G. » (Vienna, Simmering) eight-wheeled rail motor coach with one 160-H.P. Diesel engine (10 vehicles in service).

— 160-H.P. (8 cylinders) Simmering Diesel engine.

— Electrical transmissions of various designs.

— 2 driving compartments.

— 64 seats. Weight, 32 t. (31.5 Engl. tons).

— Maximum speed : 80 km. (50 miles) an hour.

Austro-Daimler four-wheeled rail motor coach with two 80-H.P. Austro-Daimler petrol engines (6 vehicles in service).

— 2 Austro-Daimler 80-H.P. petrol engines, 3 000 r.p.m. (6 cylinders).

— Austro-Voith hydraulic transmission with electro-pneumatic control.

— 2 driving compartments.

— 45 seats. Weight, 10.5 t. (10.3 Engl. tons).

— Maximum speed : 105 km. (65.2 miles) an hour.

Austro-Daimler eight-wheeled rail motor coach with two 80-H.P. Austro-Daimler petrol engines (4 vehicles under construction).

— Two 80-H.P. Austro-Daimler petrol engines at 3 000 r.p.m. (6 cylinders).

— Austro-Voith hydraulic transmission with electro-pneumatic control.

— 2 driving compartments.

— 74 seats. Weight, 19.0 t. (18.7 Engl. tons).

— Maximum speed : 100 km. (62 miles) an hour.

Oil-hydraulic brake, electro-magnetic brake.

AUSTRIA

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order. t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
				In service.					
				2 railcars with one 50-H.P. and 75-H.P. petrol engine.					
Mech.	Various.	40 and 50 *(25 and 31)*	4	14 *(13.8)*	Rev. Trailer.	50	1924 1925	35 000 *(21 750)*	Local.
				3 railcars of various designs with one 100-H.P. petrol engine.					
Mech.	Various.	50 *(31)*	4	20 and 22 *(19.7 and 21.6)*	Rev. Trailer.	50 to 60	1927	28 000 to 40 000 *(17 400 to 25 000)*	Local.
				2 railcars of various designs with one 100-H.P. petrol engine.					
Mech.	Various.	40 and 55 *(25 and 34)*	8	18 and 27 *(17.7 and 26.6)*	Rev. Trailer.	55 and 70	1925 1929	13 000 to 26 000 *(8 080 to 16 160)*	Local.
				5 railcars of various designs with one 150-H.P. petrol engine.					
Mech.	Various.	50 to 60 *(31 to 37.3)*	8	27 to 33 *(26.6 to 32.5)*	Rev. Trailer.	76 to 82	1926 1927	40 000 *(25 000)*	Local.
				1 Wien railcar with two 60-H.P. petrol engines.					
Mech.	Fross-Büssing, Vienna.	50 *(31)*	4	21 *(20.7)*	Rev. Trailer.	58	1927	36 000 *(22 370)*	Local.
				1 Grazer Waggonbau und Maschinenfabrik A.G. (Graz railcar with one 200-H.P. Grazer Diesel engine.					
Electr.	A.E.G.	45 *(28)*	6	39 *(38.4)*	Rev. Trailer.	70	1927	21 000 *(13 050)*	Local.
				1 Maschinen- und Waggonfabrik A.G. (Simmering, Vienna) railcar with one 100-H.P. petrol engine.					
Electr.	Deutsche Werke, Kiel.	40 *(25)*	4	24 *(23.6)*	Rev. Trailer.	55	1930	29 000 *(18 000)*	Local.
				1 Wiener Lokomotivfabrik A.G. (Floridsdorf, Vienna) railcar with one S.E.G. (Vienna) 120-H.P. petrol engine.					
Electr.	Brown-Boveri.	40 *(25)*	4	12 *(11.8)*	Rev. Trailer.	55	1930	22 000 *(13 700)*	Local.

Transmission.		Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order. t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service
Type.	Builders.								
1 Grazer Waggonbau u. Maschinenfabrik A.G. railcar with one 200-H.P. Diesel engine.									
Electr.	Siemens.	35 *(21.7)*	8	34 *(33.5)*	Rev.	55	1930	12 000 *(7 450)*	Local.
*10 Maschinen- u. Waggonbaufabrik A.G. (Simmering, Vienna) railcar with one 160-H.P. Diesel engine.**									
Electr.	Various.	80 *(50)*	8	32 *(31.5)*	Rev. Trailer.	64	1933	30 000 *(18 650)*	Fast local
4 Perl Automobilfabrik A.G. (Liesing) railcars with one 85-H.P. petrol engine.									
Mech.	Perl.	45 *(28)*	4	6.4 *(6.3)*	Rev. Trailer.	27	1933	25 000 *(15 550)*	Local.
1 Austro-Daimler railcar with one 80-H.P. Austro-Daimler engine.									
Mech.	Austro-Daimler.	100 *(62)*	4	6.2 *(6.1)*	Rev. Trailer.	24	1932	55 000 *(34 200)*	Fast local
10 Grazer Waggonbau- u. Maschinenfabrik A.G. (Graz) railcars with one 300-H.P. Grazer Diesel engine.									
Electr.	Various.	65 *(40.4)*	4	27 *(26.6)*	Rev. Trailer.	45	1933	4 000 *(2 500)*	Local.
*6 Austro-Daimler railcars with two 80-H.P. Austro-Daimler petrol engines.**									
Hydr.	Austro-Daimler.	105 *(65.2)*	4	10.5 *(10.3)*	Rev. Trailer.	45	1933	10 061 *(6 125)*	Fast local
Under trial or construction.									
*4 Austro-Daimler railcars with two 80-H.P. Austro-Daimler petrol engines.**									
Hydr.	Austro-Daimler.	100 *(62)*	8	19 *(18.7)*	Rev. No trail.	74	1933	...	...

* *Note.* — Railcars marked * have been described in the text.

Belgium.

The Belgian National Railways Company has 27 rail motor coaches operating at the present time slow and speeded-up stopping services and one 410-H.P. fast twin unit covering through services between Brussels (Midi) and Ghent (St. P.) (1). Five further rail motor coaches have been ordered.

All these rail motor coaches run in either direction and have two driving compartments. They are not intended to haul trailers as a rule.

Furthermore, the Company has tendered out six 3-coach units for express trains, equipped with two 410-H.P. Diesel engines.

They will all be fitted with Westing-

(1) In service since May 22nd, 1934.

house compressed air brakes and, like the 410-H.P. twin coach, will also be fitted with a hand-operated compressed-oil brake (stand-by brake). The electro-magnetic brake is not used.

Four of the rail motor coaches in service are steam-driven (3 Sentinel and 1 Birmingham).

The 5 rail motor coaches on order will have Diesel engines. Four of them will have mechanical transmission, the other electrical transmission. They will run in either direction, and, like the above mentioned vehicles, be fitted with Westinghouse compressed-air brake.

E. V. A. rail motor coach with 2 bogies (3 vehicles in service).

— 1 Maybach Diesel engine, 175-H.P. at 1 400 r.p.m. (6 cylinders).
— 92 seats. Weight, 38 t. (37.4 Engl. tons).

Prototyple of the « La Brugeoise » rail motor coach described below.

« La Brugeoise » rail motor coach with 2 bogies (14 vehicles in service).

— One 175-H.P. Maybach Diesel engine, 1 400 r.p.m. (6 cylinders).
— 4-stroke, compressed-air injection.
— Radiator carried under the frame of the vehicle, behind the driving bogie.
— Maybach mechanical transmission.
— Maybach constant-mesh gear box, oil pressure controlled, driving a jack shaft driving in turn the 2 axles of the driving bogie by outside connecting rods.

The driving bogie is shown is fig. 57.

— 104 seats. Weight: 32 t. (31.5 Engl. tons).
— Heating by « Ideal Classic » boiler and hot water pipes.
— Maximum speed : 80 km. (50 miles) an hour.
— Gas-oil consumption: 350 gr./km. (1.242 lb. per mile) on the level.

The Belgian National Railways Company have found these vehicles completely satisfactory. We give below the cost for 1933 :

Total annual mileage of the 14 rail motor coaches in commercial service	1 247 272 km. *(775 033 miles).*	
Average mileage per rail motor coach and per day in service	268 km. *(166.5 miles).*	
	Expenditure :	
	Per km.	*Per mile.*
Train staff, and shed staff (cleaning, etc.)	0.61	*0.98*
Fuel, lubricants	0.28	*0.45*
Maintenance, running repairs	0.31	*0.50*
Total	1.20	*1.93*
	Francs (Belgian currency).	

Note. — As the engines were still new, there was no expenditure on heavy repairs, or exceptional repairs.

Sentinel steam rail motor coaches on 2 bogies (3 vehicles in service) (fig. 62).

— 100 H.P. at 500 r.p.m.
— 62 seats (1st and 2nd class).
— Maximum speed : 85 km. (52.8 miles) an hour. Weight : 34.5 t. (33.9 Engl. tons).

The Sentinel steam rail motor coaches are similar to those used on the London & North Eastern Railway.

As at the end of 1933, the Sentinel steam rail motor coaches and the E.V.A. Maybach rail motor coaches had approximately the same average mileage to their credit (400 000 km. = 250 000 miles approximately), it is interesting to compare the working cost of these two types of rail motor coach during the years 1932 and 1933.

	Sentinel, 100 H.P., steam.		E.V.A. Maybach, 175 H.P.	
Number of vehicles	3		3	
Total average mileage	377 000 km. *(234 260 miles).*		387 000 km. *(240 475 miles).*	
	1932	*1933*	*1932*	*1933*
Average daily mileage	295 km. *(183.3 miles)*	372 km. *(237.4 miles)*	299 km. *(185.8 miles)*	*323 km. (200.7 miles)*
Consumption per km. (per mile).				
Fuel-oil	...	...	...	392 gr. *(0.864 lb.)*
Coal	...	3.744 kgr. *(8.254 lb.)*	...	...
Lubricating oil. cylinders	...	6 gr. *(0.34 oz.)*	...	17 gr. *(0.96 oz.)*
Lubricating oil. casing	...	3 gr. *(0.17 oz.)*	...	...
Lubricating oil. motion	...	5 gr. *(0.28 oz.)*	...	5 gr. *(0.28 oz.)*
Operating cost per km. (in Belgian francs).				
Fuel	0.52 *(0.837)*	0.47 *(0.756)*	0.18 *(0.290)*	0.22 *(0.354)*
Water	0.01 *(0.016)*	0.01 *(0.016)*	...	...
Lubricant	0.09 *(0.145)*	0.07 *(0.113)*	0.09 *(0.145)*	0.06 *(0.097)*
Train staff including general shed costs	1.42 *(2.285)*	1.18 *(1.899)*	0.58 *(0.933)*	0.50 *(0.805)*
Preparation costs (shed work)	0.10 *(0.161)*	0.09 *(0.145)*	0.08 *(0.129)*	0.06 *(0.097)*
Maintenance and repairs	0.44 *(0.708)*	0.53 *(0.853)*	0.95 *(1.529)*	1.40 *(2.253)*
	2.58 *(4.152)*	2.35 *(3.782)*	1.88 *(3.026)*	2.24 *(3.606)*

(The operating costs given above do not include the amortisation of the rail motor coaches).

This table shows that, for a long mileage, the steam rail motor coach appears to be better than the Diesel, at least as far as maintenance and repair costs are concerned.

The saving obtained in the case of the Diesel by the use of one man only to drive them is absorbed by the additional cost of maintenance and repairs.

It must be pointed out however that, according to the latest information received, the Sentinel rail motor coaches will have to undergo heavy repairs after 400 000 km. (250 000 miles), which will considerably increase their cost by the additional expenditure involved, whereas such expenditure is already included in the cost of the Diesel rail motor coaches.

Birmingham steam rail motor coach on 2 bogies (one vehicle in service).

— 175 H.P., at 600 r.p.m.

— One bogie carries both the boiler which is fitted transversely to the track, and the engine.

— 82 seats.

— Maximum speed : 70 km. (43.5 miles) an hour.

This first vehicle was put into service in 1933.

Fig. 62. — 100-H.P. SENTINEL rail motor coach.

A.S.E.A. rail motor coach with 2 bogies (one vehicle in service).

— 1 Burmeister & Wain 200-H.P. Diesel engine, 850 r.p.m., 2-stroke, 6 cylinders, mechanical injection.
— Motor fitted in the body.
— Radiators on the roof, with fans.
— A.S.E.A. electrical transmission.
— Two nose-suspended traction motors on the same bogie.
— 74 seats. Weight : 44 t. (43.3 Engl. tons).
— Maximum speed : 80 km. (50 miles) an hour.

Heating by means of radiators making use of the engine cooling water.

Ganz four-wheeled rail motor coach (5 vehicles in service).

— 1 Ganz Diesel engine, 120/150-H.P.
— 60 seats.
— Maximum speed : 72 km. (44.7 miles) an hour.

« *La Brugeoise* » *twin-unit rail motor coach on 3 bogies* (one vehicle of this type has recently been put into service on the Brussels-Ghent line.) (fig. 63).

— One 410-H.P. Maybach Diesel engine, 1 400 r.p.m.
— 2 bodies carried on three bogies.
— Gebus electric transmission.

Fig. 63. — La Brugeoise twin-unit rail motor coach.

— One of the outer bogies carries the Diesel engine and the generator ; the other is a carrying bogie.

— The middle bogie carries the two traction motors.

— 185 seats. Weight : 70 t. (68.9 Engl. tons).

— Maximum speed : 120 km. (75 miles) an hour.

The twin units are all-metal. They include 2nd and 3rd-class compartments. The interior decoration is strikingly artistic, veneered panels of moiré bubinga having been used in the 2nd-class compartments, and dark limba veneered panels in the 3rd class.

A small saloon fitted with folding-up seats has been arranged over the middle bogie, through which passengers pass from one unit to the other.

BELGIUM

Transmission.		Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
Type.	Builders.								
In service.									
*3 E.V.A. railcars with one 175-H.P. Maybach Diesel engine.**									
Mech.	Maybach.	70 *(43.5)*	8	38 *(37.4)*	Rev. No trail.	92	1930	296 872 *(184 470)*	Fast loca
*14 Société Anonyme La Brugeoise railcars with one 175-H.P. Maybach Diesel engine.**									
Mech.	Maybach.	80 *(50)*	8	32 *(31.5)*	Rev. No trail.	104	1933	27 488 *(17 080)*	Fast loca
*3 Sentinel railcars with one 100-H.P. Sentinel steam engine.**									
...	...	85 *(52.8)*	8	34.5 *(33.9)*	Rev. No trail.	62	1930	287 547 *(178 676)*	Fast loca

* *Note.* — Railcars marked * have been described in the text.

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
*1 Birmingham railcar with one 175-H.P. Yorkshire steam engine.**									
...	...	70 *(43.5)*	8	43.7 *(43.0)*	Rev. No trail.	82	1933	25 234 *(15 680)*	Fast local.
*1 A.S.E.A. railcar with one 200-H.P. Burmeister & Wain Diesel engine.**									
Electr.	A.S.E.A.	80 *(50)*	8	44 *(43.3)*	Rev. No trail.	74	1932	143 570 *(89 210)*	Fast local.
*5 Ganz railcars with one 120-150 H.P. Diesel Ganz engine.**									
Mech.	Ganz.	72 *(44.7)*	4	15.5 *(15.2)*	Rev. No trail.	60	1934	...	Local.
*1 La Brugeoise railcar with one 410-H.P. Maybach Diesel engine.**									
Electr.	Gebus.	120 *(75)*	12	70 *(68.9)*	Rev. No trail. Twins.	185	1934	...	Express.
Under trial or construction.									
1 La Dyle railcar with one 140-H.P. M.A.N. Diesel engine.									
Mech.	T.A.G. (Berlin).	80 *(50)*	2	16.5 *(16.2)*	Rev. No trail.	60	...	...	Fast local.
1 La Brugeoise railcar with one 210-H.P. Maybach Diesel engine.									
Mech.	Maybach.	80 *(50)*	8	30 *(29.5)*	Rev. No trail.	104	...	...	Fast local.
1 La Brugeoise railcar with one 210-H.P. Maybach Diesel engine.									
Electr.	A.C.E.C. (Charleroi).	80 *(50)*	8	30 *(29.5)*	Rev. No trail.	104	...	...	Fast local.
1 Baume-Marpent railcar with one 320-H.P. Carels-Ganz Diesel engine.									
Mech.	S.L.M. (Winterthur).	90 *(56)*	8	22 *(21.7)*	Rev. No trail.	70	...	...	Fast local.
1 S.E.M. railcar with one 220-H.P. Carels-Ganz Diesel engine.									
Mech.	Ganz.	80 *(50)*	8	25 *(24.6)*	Rev. No trail.	104	...	...	Fast local.

* *Note.* — Railcars marked * have been described in the text.

Denmark.

Denmark has been gradually developing its rail motor coach services since 1925, and its stock now consists of 66 such vehicles, including 56 petrol-engined, and 10 Diesel-engined rail motor coaches.

The first vehicles put into service had a single driving compartment, and con-

sequently could only run in one direction. As a result, they were often used in pairs. Frequently one, two or even three trailers were put between two rail motor coaches in order to make up a small train with a driving unit at each end. As the two driving units were not connected together, a single engine was used to haul the train.

The first rail motor coaches equipped with Diesel engines date from 1928. From the beginning, the designers (Frichs of Aarhus) placed the engine on one of the bogies and used electric transmission. The first vehicles gave rise to some difficulties before they were perfected, but in 1932 Messrs. Frichs brought out 4 rail motor coaches with 220-H.P. Diesel engine which gave immediate satisfaction.

Odense rail motor coach with two 100-H.P. Continental petrol engines
(16 vehicles in service).

— Two 100-H.P. Continental petrol engines.
— Thrige Odense electric transmission.
— The two engines and the two generators are carried on one of the bogies, and the two traction motors on the other.
— Can run in either direction. A driving compartment at each end.
— 70 seats. Weight : 42 t. (41.3 Engl. tons).
— Maximum speed : 80 km. (50 miles) an hour.
— Heating by an auxiliary coke boiler.

Frichs rail motor coach with one 220-H.P. Frichs Diesel engine
(4 vehicles in service).

— One 220-H.P. Frichs Diesel engine.
— Titan electric transmission, Copenhagen (Léonard type).
— One bogie carries the Diesel engine and the generator, the other the two traction motors.
— Can haul one or two trailers.
— 70 seats. Weight : 55 t. (54.1 Engl. tons).
— Maximum speed : 100 km. (62 miles) an hour.
— Independent heating by means of hot water pipes from a coke boiler.

Frichs rail motor coaches with two 220-H.P. Frichs Diesel engines
(10 vehicles on order).

— Two 220-H.P. Frichs Diesel engines — 6 cylinders.
— Titan electric transmission.
— Two 6-wheeled bogies, one carrying the two Diesel engines and the two generators, the other the two traction motors driving the two outer wheels of the bogie.
— 70 seats. Weight : 56 t. (55.1 Engl. tons).
— Can haul one or two trailers.
— Maximum speed : 120 km. (75 miles) an hour.
— Cooled by radiators in the roof.

The first of these rail motor coaches was tested in January 1934, and the starting curve on the level (fig. 64) was obtained with a total weight of 56 t. (55.1 Engl. tons) and with the engines developing a power of 445 H.P.

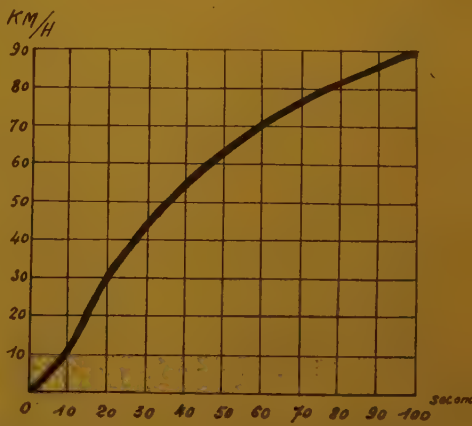


Fig. 64. — Starting curve of the 440/480-H.P. FRICHS Diesel rail motor coach.

DENMARK

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
				In service.					
				38 Odense railcars with one 80-H.P. Continental petrol engine.					
Mech.	Forenede Automobil Fabriker, Odense.	70 *(43.5)*	4	14 *(13.8)*	Rev. Twins. Trailer.	33	1926 1927 1928 1929	400 000 *(250 000)*	Local.
				2 Odense railcars with two 80-H.P. Continental petrol engines.					
Mech.	Forenede Automobil Fabriker, Odense.	55 *(34.2)*	6	19 *(18.7)*	Rev. Twins. Trailer.	50	1926	300 000 *(186 000)*	Local.
				*16 Odense railcars with two 100-H.P. Continental petrol engines.**					
Electr.	Thrige, Odense.	80 *(50)*	8	42 *(41.3)*	Rev. Trailer.	60-70	1928 1930	200 000 to 500 000 *(124 000 to 310 000)*	Fast local. Express.
				6 Frichs railcars with one 160-H.P. Frichs Diesel engine.					
Electr.	Siemens.	80 *(50)*	8	44 *(43.3)*	Rev. Trailer.	60	1928	300 000 *(186 000)*	Local. Express.
				*4 Frichs railcars with one 220-H.P. Frichs Diesel engine.**					
Electr.	Titan.	100 *(62)*	12	55 *(54.1)*	Rev. Trailer.	70	1932	70 000 *(43 500)*	Fast local.
				Under construction.					
				*10 Frichs railcars with two 220-H.P. Frichs Diesel engines.**					
Electr.	Titan.	120 *(75)*	12	56 *(55.1)*	Rev. Trailer.	70	...	...	Fast local. Express.

* *Note.* — Railcars marked * have been described in the text.

Finland.

The Finnish State Railways have ten rail motor coaches, only two of which have petrol engines, and are used in stopping service. All these vehicles can run in either direction, and can haul one or several trailers.

All the engines are four-stroke (6 cylinders). The radiators are in the roof.

In the event of intense cold, the radiators can be protected by revolving shutters or by felt covers; some of the radiators can be cut out.

FINLAND

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
In service.									
2 N.A.G. railcars with one 75-H.P. N.A.G. petrol engine.									
Mech.	N.A.G.	45 *(28)*	4	20 *(19.7)*	Rev. Trailer.	42	1928	226 200 *(140 560)*	Local.
3 railcars with one 85-H.P. Atlas Diesel engine.									
Electr.	A.S.E.A.	56 *(34.8)*	8	33 *(32.5)*	Rev. Trailer.	50	1928-1930	295 700 *(183 740)*	Local.
5 railcars with one 150-H.P. M.A.N. Diesel engine.									
Electr.	A.E.G.	75 *(46.6)*	8	46 *(45.3)*	Rev. Trailer.	60	1933	62 195 *(38 650)*	Local.

France.

On the 1st July 1934, the French Railways owned 115 rail motor coaches in service and had 137 more under trial or construction.

They consider that rail motor coaches will play a considerable part in the future of the railway and have therefore carried out extensive tests of the various original designs submitted, before the best types to adopt have been definitely decided upon.

Even a certain number of designs has been selected for construction on mass-production lines. Thus Messrs. Renault have been given an order for 100 bogie vehicles for various Railways, and Messrs. DE DIETRICH have about 50 vehicles under construction. Messrs. MICHELIN are building a series of Micheline with 36 seats, as the comfort of these vehicles (smooth running which only pneumatic tyres have given up to the present) and their acceleration are much appreciated by the public.

36-seater Michelines (6 pairs of wheels) (14 vehicles in service, 11 under trial and construction, for the French State, Est and Nord Railways).

— One 185-H.P. Hispano petrol engine, 2 600 r.p.m. (12 cylinders arranged in V), mechanical transmission, Panhard gear box, 4 speeds.

1 driving compartment which is raised above the vehicle so that it can run in either direction.

Two 6-wheeled bogies on pneumatic tyres.

36 seats. Weight, 7.5 t. (7.4 Engl. tons).

Maximum speed: 100 km. (62 miles) an hour.

Heating by circulating hot air heated by the engine cooling water.

Lockheed hydraulic brake.

Messrs. MICHELIN have also built a 32-seater Micheline, equipped with the Hispano engine ; this vehicle, the rear part of which is streamlined, can only be run in one direction. It has approxim-

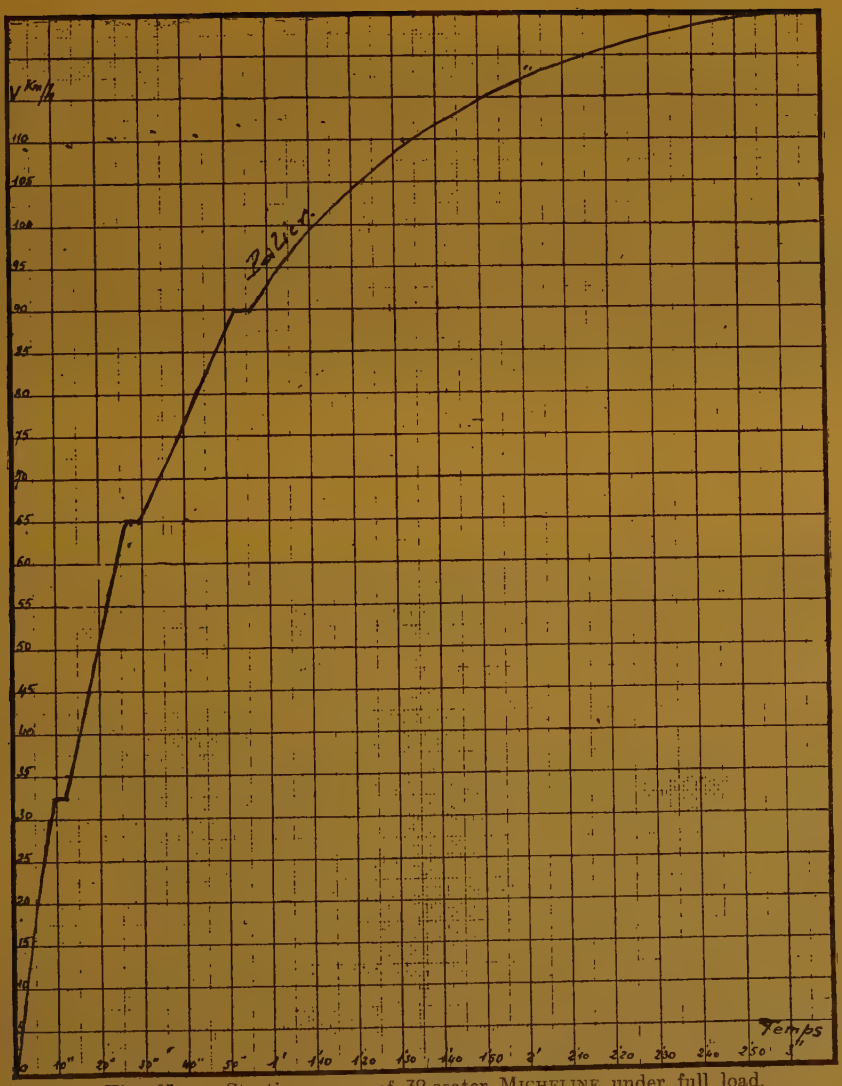


Fig. 65. — Starting curve of 32-seater MICHELINE under full load.
Note: Palier = On the level.

ately the same length and weight as the 36-seater. Figure 65 shows its starting curve. Fully loaded it reaches the speed of 80 km. (50 miles) an hour in 42 seconds.

Pauline No. 2 (Entreprises industrielles Charentaises) with four pairs of wheels (17 vehicles in service, 8 of them on the Midi Railway) (fig. 67).

One C.L.M. Diesel engine, 80 H.P. at 1 500 r.p.m., 3 cylinders with opposed pistons ; mechanical transmission with Minerva gear box giving 5 speeds.

Two driving compartments.

Fig. 66. — 56-seater MICHELINE.

Fig. 67. — PAULINE No. 2.

The whole of the underframe and body framing is made of duralumin.

50 seats. Weight, 10.2 t. (10 Engl. tons).

Maximum speed, 90 km. (56 miles) an hour.

Heating by the engine cooling water. Charlestop brake, with hydraulic transmission.

*Renault rail motor coach with four pairs of wheels and a 220-*H.P. *Renault Diesel engine* (power soon to be increased to 265 H.P.) (fig. 68).

(115 vehicles in service or under construction, 15 of them with 2.20 m. [7 ft. 3 in.] and 66 with 2.50 m. [8 ft. 2 7/16 in.] wheel base bogies for all the railway systems).

One 12-cylinder V-type Renault Diesel engine.

Renault mechanical 4-speed transmission (fig. 25).

2 driving compartments.

56 seats. Weight, about 27 t. (26.6 Engl. tons).

Maximum speed, 120 km. (75 miles) an hour.

Compressed air brake and electro-magnetic brakes.

Heating by the exhaust gases.

de Dietrich rail motor coach with four pairs of wheels (1 vehicle in service, about 50 under construction, for most of the French railways).

Two C.L.M. Diesel engines, 105 H.P., at 1 500 r.p.m., 4 cylinders with opposed pistons.

Fig. 68. — RENAULT rail motor coach.

Mylius 4-speed mechanical transmission, with pneumatic control.

Four pairs of L.B.-system elastic wheels (fig. 49). Bogie shown in fig. 53.

Two driving compartments.

75 seats. Weight, 26 t. (25.6 Engl. tons). Maximum speed, 100 km. (62 miles) an hour.

Jourdain-Monneret-Lockheed oil-pneumatic brake. Electro-magnetic brake.

Heating by independent oil-fired boiler.

*Bugatti rail motor coach with four 200-*H.P. *engines.*

(12 vehicles, 3 of which in service on the State, Paris-Lyons & Mediterranean, and Alsace-Lorraine).

Four Royal Bugatti petrol engines, 200 H.P. at 2 500 r.p.m. (8 cylinders) carried in a central compartment and fitted at right angles to the longitudinal axis of the vehicle (fig. 31).

Each engine has à Daimler hydraulic clutch and bevel reverse gear (fig. 32).

Central raised driving compartment to allow of running in either direction.

Two bogies with four pairs of wheels. Two driving axles per bogie. Elastic wheels.

60 seats. Weight, 25 t. (24.6 Engl. tons).

Maximum speed, 150 km. (93 miles) an hour. In the course of the trials, the speed of 178 km. (110.6 miles) was reached.

Compressed air and hand brakes.

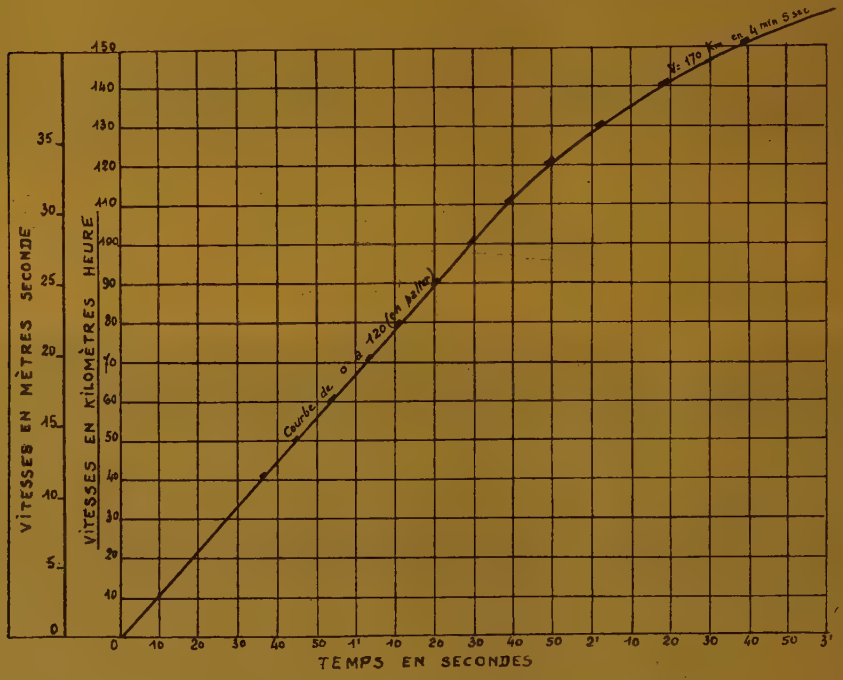

VITESSES EN MÈTRES SECONDE
VITESSES EN KILOMÈTRES HEURE
TEMPS EN SECONDES
Courbe de 0 à 120 (en Mètres)
V: 170 Km en 4 min 5 sec

Fig. 69. — Starting curve — under full load — of the 800-H.P. BUGATTI twin-unit rail motor coach, French State Railways.

Note : Vitesse en mètres seconde = Speed, metres per second. — Vitesse en kilomètres... = Speed, km. per hour. — Courbe de 0... = Curve from 0 to 120 km. (75 miles) on the level. — V : 170 km... = Speed : 105.6 miles an hour in 4 min. 5 sec. — Temps en secondes = Time in seconds.

The starting curve of this vehicle is shown in figure 69.

The Bugatti rail motor coaches of the Paris-Lyons & Mediterranean Railway (fig. 70) haul a trailer and can run at high speed with the trailer in front. The Bugatti rail motor coaches under construction for the Alsace-Lorraine Railways will only have two engines developing 200 H.P. each.

Franco-Belge rail motor coach sets belonging to the Nord Company (fig. 71).

Each set consists of three units, each on two bogies; two are driving units and there is a trailer in the middle.

Each unit is carried on two bogies so that the sets can be of two or three units according to traffic requirements.

Fig. 70. — Paris-Lyons and Mediterranean Railway's BUGATTI rail motor coach with its trailer.

Fig. 71. — FRANCO-BELGE three-coach set.

Each driving unit has a Maybach Diesel engine developing 380 H.P. at 1 350 r.p.m., coupled directly to the generator, both of them being carried on the outer bogie of the set.

Gebus electric transmission, modified by the Franco-Belge Company.

140 seats, about 62 of which in the trailer.

Weight, 117 t. (115.1 Engl. tons).

Maximum speed, 150 km. (93 miles) an hour.

Heating by independent coke-fired boiler.

Jourdain - Monneret - Lockheed brake with braking action proportionate to the speed.

Electro-magnetic brake making it possible to stop in emergency in 540 m. (590 yards) from a speed of 140 km. (87 miles) an hour.

S.O.M.U.A. 4- and 6-wheeled rail motor coaches (fig. 72)

Two S. O. M. U. A. four-wheeled rail motor coaches and a six-wheeled S. O. M. U. A., the third pair of wheels carrying a trailer, are in service on the Paris-Lyons & Mediterranean and the French State Railways. These rail motor coaches are of the automobile type with loose wheels on fixed axles, no axle guards being fitted.

Fig. 72. — S.O.M.U.A. 6-wheeled articulated rail motor coach.

4-wheeled rail motor coaches of the Compagnie Générale de Construction (four units in service on the P.L.M.).

One 6-cylinder M.A.N. Diesel engine, 150 H.P. at 1 500 r.p.m.

One central driving compartment raised above the roof.

Mechanical transmission, 4-speed gear box with sliding pinions.

44 seats. Weight, 17.7 t. (17.4 Engl. tons).

Maximum speed : 90 km. (56 miles) an hour.

Experimental bogie rail motor coaches built by the « Aciéries du Nord (A. D. N.) » with M.A.N. Diesel engine (six vehicles in service).

The Aciéries du Nord have designed, for several French railway systems, strongly-built high-power trial rail motor coaches of the railway type with M. A. N.-ACENOR engines and Wintherthur mechanical or electric transmission (Jeumont or A.S.E.A.).

These experimental vehicles weigh 32

to 37 t. (31.5 to 36.4 Engl. tons) and can run at 100 to 120 km. (62 to 75 miles) an hour according to their design.

The driving bogie of the A.D.N. coach built for the Nord Railway is shown in figure 55.

Secondary and Colonial Railways.

The secondary French railways have many rail motor coaches in service and under construction.

Special mention must be made of the rail motor coaches designed by the « Société Centrale de Chemins de fer et d'Entreprises » ; those designed by the « Compagnie Générale de Construction de Batignolles-Châtillon » ; the Brissonneau rail motor coaches with electric transmission ; the small A. Laborie rail motor coach with pneumatic tyres ; and the battery-driven coaches of the Sud-Ouest Railway.

The Algerian Railways have 8 rail motor coaches in service, and two under construction.

The Madagascar Railways have two 18-seater Michelines in operation for express services between Tamatave and Tananarive.

The Congo-Océan Railway has just ordered some Billard rail motor coaches, with Berliet engine, the trials of which have just been ended.

FRANCE

Transmission.		Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
Type.	Builders.								
In service.									
9 Micheline railcars with one 95-H.P. Panhard petrol engine.									
Mech.	Panhard.	95 *(59)*	10	4.7 *(4.6)*	Not rev. No trail.	24	1932	168 000 *(104 400)*	...
*14 Micheline railcars with one 185-H.P. Hispano petrol engine.**									
Mech.	Panhard.	100 *(62)*	12	7.5 *(7.4)*	Rev. No trail.	36	1933-1934	46 000 *(28 580)*	...
*14 Renault railcars with one 85-H.P. Renault Diesel engine (State).**									
Mech.	Renault.	90 *(56)*	4	11 *(10.8)*	Not rev. No trail.	34	1930-31-32	109 000 *(67 730)*	...
*32 Renault railcars with one 220-H.P. Renault Diesel engine.**									
Mech.	Renault.	120 *(75)*	8	27 *(26.6)*	Rev. No trail.	56	1933-1934	40 000 *(25 000)*	...
*17 Pauline railcars with one 80-H.P. Peugeot-Junkers Diesel engine.**									
Mech.	Minerva.	90 *(56)*	8	10 *(9.8)*	Rev. No trail.	50-60	1933-1934	*47 000 (29 200)*	Local.

* *Note.* — Railcars marked * have been described in the text.

Transmission.		Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
Type.	Builders.								
2 Charentaise railcars with one 120-H.P. M.A.N. Diesel engine (Est).									
Mech.	Minerva.	100 *(62)*	8	15 *(14.8)*	Rev. No trail.	61	1934	10 000 *(6 200)*	Local
*1 de Dietrich railcar with two 100-H.P. C.L.M. Diesel engines (Alsace-Lorraine).**									
Mech.	Mylius.	100 *(62)*	8	23 *(22.6)*	Rev. No trail.	75	1933	56 600 *(35 170)*	Local
*3 Bugatti railcars with four 200-H.P. petrol engines (State).**									
Hyd.	Bugatti.	150 *(93)*	16	25 *(24.6)*	Rev. Trailer.	60	1933-1934	28 310 *(17 590)*	Expres
*2 S.O.M.U.A. railcars with one 80-H.P. Peugeot-Junkers Diesel engine (P.L.M. Ry.).**									
Mech.	S.O.M.U.A.	90 *(56)*	4	11.7 *(11.5)*	Not rev. No trail.	40	1933	27 500 *(17 090)*	Local
*1 S.O.M.U.A. railcar with one 210-H.P. M.A.N. Diesel engine (State).**									
Mech.	S.O.M.U.A.	90 *(56)*	6	28.5 *(28)*	Rev. Trailer.	75	1934	7 387 *(4 590)*	Local
*2 A.D.N. railcars with one 170-H.P. M.A.N. Diesel engine (P.L.M.).**									
Mech.	A.D.N.	100 *(62)*	8	33.6 *(33.1)*	Rev. No trail.	73	1933	60 400 *(37 530)*	Local
*2 A.D.N. railcars with one 170-H.P. ACENOR Diesel engine (P.O.).**									
Mech.	A.D.N.	120 *(75)*	8	31 *(30.5)*	Rev. No trail.	65	1934	27 700 *(17 210)*	Local
*2 A.D.N. railcars with one 250-H.P. M.A.N. Diesel engine (Nord).**									
Electr.	1 A.S.E.A. 1 Jeumont.	100 *(62)*	8	30 *(29.5)*	Rev. No trail.	66	1934	4 800 *(2 983)*	Local
4 Baudet-Donon-Roussel railcars with one 100-H.P. Peugeot-Junkers Diesel engine (P.L.M.).									
Mech.	Glaenzer-Spicer. Cotal box.	90 *(56)*	4	12.5 *(12.3)*	Rev. Twins.	40	1934	...	Local
2 Decauville railcars with two 140-H.P. Saurer Diesel engines (Nord).									
Mech.	Winterthur.	100 *(62)*	8	26 *(25.6)*	Rev. No trail.	64	1934	4 000 *(2 500)*	Local
*4 Compagnie Générale de Construction railcars with one 150-H.P. M.A.N. Diesel engine (P.L.M.).**									
Mech.	C.G.e.Con.	90 *(56)*	4	17.7 *(17.4)*	Rev. No trail.	44	1933	30 400 *(18 890)*	Local

* *Note.* — Railcars marked * have been described in the text.

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
2 Compagnie Française de Matériel de Chemins de fer railcars with one 120-H.P. Saurer Diesel engine (P.L.M.).									
Mech.	Cie Fr. Mat. Ch. fer.	90 *(56)*	4	17.4 *(17.1)*	Rev. No twins.	43	1934	...	Local.
*2 Franco-Belge three-coach sets with two 380-H.P. Maybach Diesel engines (Nord).**									
Electr.	Gebus. Fr.-B.	150 *(93)*	24	117 *(115.1)*	Rev. Trailer.	140	1934	...	Express.
Under trial or construction.									
17 Micheline railcars (11 with 36 seats, 6 with 56), with one Hispano petrol engine (about 200-H.P.) (State, Est, P.-O.).									
Mech.	Panhard.	100 *(62)*	12 16	6.5 *(6.4)* 7.9 *(7.8)*	Rev. No trail.	36 56	... ...	... ...	... ...
9 Bugatti railcars with four 200-H.P. Bugatti petrol engine, with trailer.									
...	Bugatti.	150 *(93)*	32	54 *(53.1)*	Rev.	74	...	...	...
4 Bugatti railcars with two 200-H.P. Bugatti petrol engines.									
...	Bugatti.	130 *(80.8)*	16	20 *(19.7)*	Rev. No trail.	72	...	...	...
*49 Renault railcars with one 220-H.P. Renault Diesel engine.**									
Mech.	Renault.	105 *(65.2)*	8	28 *(27.5)*	Rev. No trail.	42 to 70	...	...	...
*31 de Dietrich railcars with two 100-H.P. C.L.M. Diesel engines.**									
Mech.	Mylius.	100 *(62)*	8	26 *(25.6)*	Rev. No trail.	50 to 75	...	...	...
4 Charentaise railcars with one 100-H.P. Junkers Diesel engine (P.O., Midi).									
Mech.	Minerva.	90 *(56)*	4	8 *(7.9)*	Rev. No trail.	40	...	...	...
4 Charentaise railcars with two 140-H.P. Saurer Diesel engines (State).									
Mech.	Minerva.	120 *(75)*	8	25 *(24.6)*	Rev. No trail.	82	...	...	...
2 Baudet-Donon-Roussel railcars with one 135-H.P. CODRA Diesel engine (State).									
Mech.	B.D.R. Cotal gear box.	100 *(62)*	4	16 *(15.8)*	Rev. Twins.	38	...	...	...
2 Baudet-Donon-Roussel railcars with two 135-H.P. CODRA Diesel engines (Nord).									
Mech.	Cotal gear box.	100 *(62)*	8	26 *(25.6)*	Rev. No trail.	65	...	...	...

* *Note.* — Railcars marked * have been described in the text.

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
2 Baudet-Donon-Roussel railcars with one 100-H.P. C.L.M. Diesel engine (P.O.).									
Mech.	Cotal	90 *(56)*	4	11 *(10.8)*	Rev. No trail. Twins.	40	...	...	...
*4 A.D.N. railcars with one 280-H.P. ACENOR Diesel engine (P.O.).**									
Mech.	Winterthur.	120 *(75)*	8	32 *(31.5)*	Rev. No trail.	64	...	...	...
*2 A.D.N. railcars with one 210-H.P. M.A.N. Diesel engine (State).**									
Mech.	Winterthur.	105 *(65.2)*	8	30 *(29.5)*	Rev. No trail.	74	...	...	...
2 Compagnie Française de Matériel de Chemins de fer railcars with two 140-H.P. Saurer Diesel engines (Nord).									
Electr.	Oerlikon.	100 *(62)*	12	30 *(29.5)*	Rev. No trail.	62	...	...	...
2 Delaunay-Belleville railcars with one 5-H.P. Delaunay Diesel engine (P.L.M.).									
Mech.	Delaunay-Belleville.	90 *(56)*	4	11.7 *(11.5)*	Not rev. No trail.	40	...	...	...
2 Batignoles-Bacalan railcars with two 135-H.P. CODRA Diesel engines (Est).									
Mech.	Winterthur.	100 *(62)*	8	29 *(28.5)*	Rev. No trail.	60	...	...	...
1 Ateliers du Nord de la France steam railcar, with 300-H.P. Sentinel engine (Nord).									
Mech.	...	95 *(59)*	8	44 *(43.3)*	Rev. No trail.	65	...	...	...

* *Note.* — Railcars marked * have been described in the text.

Holland.

At the end of 1929 the Netherlands Railways had a stock of 34 rail motor coaches :

20 with four, and 14 with two pairs of wheels.

26 with petrol engines, and 8 with Diesel engines. Their power is about 100 H.P., and they all have mechanical transmission.

The experience obtained by the Netherlands Railways in operating these rail motor coaches led them to the conclusion that, from the economical point of view, engines using gas oil were better and that high-speed, high-capacity coaches were needed.

On the other hand, the recent improvement of the highway system made competition from road transport more severe.

Consequently, early in 1933, the Netherlands Railways passed a large order for 40 sets of three-unit rail motor

Fig. 73. — Dutch three-coach set.

coaches each fitted with two 410-H.P. Diesel engines.

On the 1st July 1934, i.e. less than 18 months later, 28 three-unit sets were already in service, and replaced many steam train services quite satisfactorily.

The results are very much to the credit of the Netherlands Railways and their Chief Mechanical Engineer, Mr. Hupkes.

Three-unit rail motor coach on 4 bogies, with two 380-H.P. Maybach Diesel engines and electric transmission (fig. 73).
(40 sets, five of them with GANZ engines).

Each of these rail motor coaches is a set of three bodies connected up with diaphragms, and carried on four bogies; the three units form a single indivisible unit, somewhat like the German « Schnelltriebwagen », but larger.

Each of the intermediate bogies has two separate centres very near each other, on which the two bodies carried on them rest.

The Diesel engines and the electrical equipment are carried in the middle body. Owing to the weight of this unit, the two bogies on which it is carried have three pairs of wheels. On each of the two intermediate bogies the two outer pairs of wheels are driven by the traction motors, the middle pair of wheels being a carrying pair.

The two outer bogies of the set are simply carrying bogies.

There is a driving compartment at each end of the set. The number of seats is 48-second class and 112-third class, i.e. 160 altogether.

The weight of the set, in running order but empty, is 97 t. (95.5 Engl. tons) and its maximum speed is 140 km. (80.7 miles) an hour. Each rake is fitted at each end with a Scharfenberg automatic coupling device which automatically couples up the electrical and pneumatic connections between two trains and makes it possible to connect two sets together and drive them by a single man.

The question of heating received special attention from the Netherlands Railways and the solution adopted was very carefully thought out. On the one hand, they considered that it was impossible to heat the passenger compartments suf-

ficiently by means of the water used for cooling the engine, and on the other hand, it was necessary to park these vehicles in open sidings.

The essential feature of the system adopted is a water circuit which links together : the radiators used for cooling the engines, a small oil-fired boiler, an air heater, and a small circulating pump. Each of these different parts can be cut out of circuit.

Air drawn in from the outside passes through the heater, which under normal running conditions has the water used

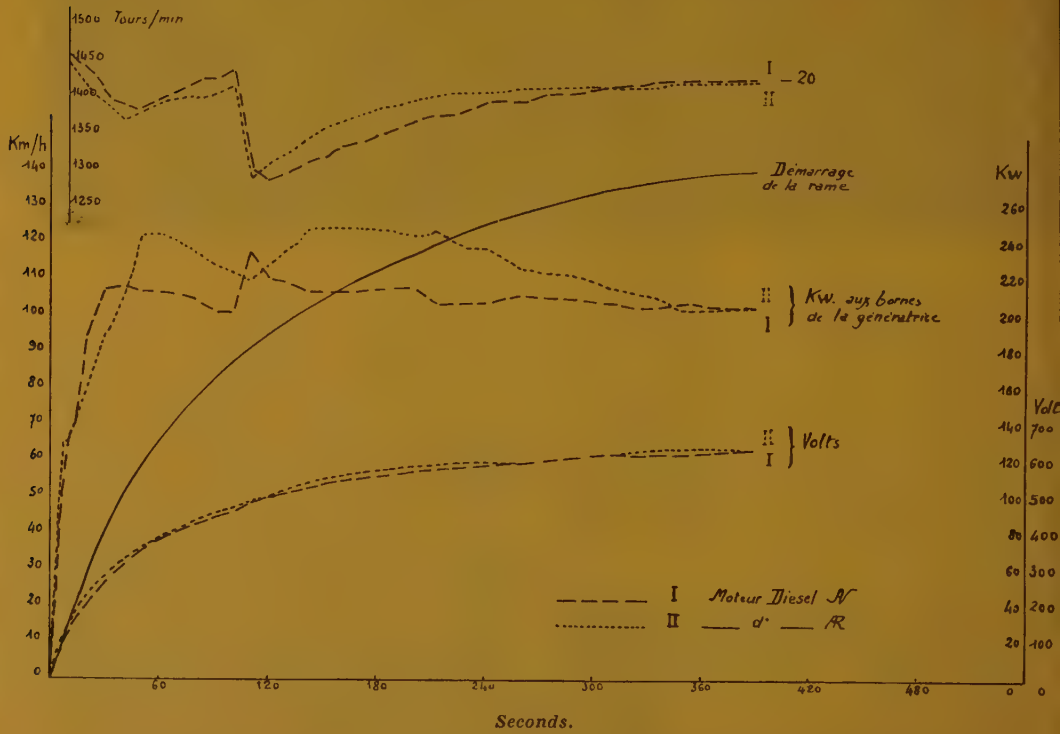


Fig. 74. — Starting curve of Dutch three-coach set.

Note. — Tours min. = r. p. m. — Démarrage de la rame = Starting curve of set. — Kw. aux bornes = Kw. at the terminals of the generator. — AV = Front. — AR = Rear.

for cooling the engines run through it, and also the water from the auxiliary boiler. The air then passes through the passenger compartments. Thermostats regulate automatically : the supply of air in terms of the temperature in the compartments, the working of the auxiliary boiler and that of the radiator fans.

In the case of long stops, when the engines are not running, the small pump working off the battery assures the circulation of the water through the engines.

We give below the very favourable starting results obtained during the trials with the 29th set on the 3rd July, 1934 (fig. 74).

HOLLAND

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order. t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
In service.									
20 two-bogie railcars of various designs with two 100-H.P. (approx.) petrol engines.									
Mech.	Various.	75 *(46.6)*	8	32 to 45 *(31.5 to 44.3)*	Rev. Twins. Trailer.	65 to 76	1923 to 1929	252 000 to 623 000 *(156 600 to 387 100)*	Local.
6 Allan railcars with one 100-H.P. Bussing petrol engine.									
Mech.	Deutsche Getriebe.	60 *(37.3)*	4	19.5 *(19.2)*	Rev. Twins. No trail.	40	1929	169 400 *(105 260)*	Local.
8 railcars of various designs with one 70-H.-P. M.A.N. Diesel engine.									
Mech.	Deutsche Getriebe.	50 *(31)*	4	18.5 *(18.2)*	Rev. No twins. No trail.	43	1927	249 000 *(154 700)*	Local.
Under trial or construction.									
*35 three-coach sets on 4 bogies, with two 380-H.P. Maybach Diesel engines.**									
Electr.	Heemaf Brown-B.	140 *(87)*	20	82 *(80.7)*	Rev. 3-coach. sets.	160	...	...	Ord. expr. Fast expr.
5 three-coach sets on 4 bogies with two 350-H.P. Ganz Diesel engines.									
Electr.	Westing-house.	140 *(87)*	20	82 *(80.7)*	Rev. 3-coach. sets.	160	...	...	Ord. expr. Fast expr.

* *Note.* — The 3-coach sets marked * are described in the text.

Royal Hungarian State Railways.

At the present time, the Royal Hungarian State Railways have 103 rail motor coaches (98 of which have two or three pairs of wheels, and 5 four pairs of wheels).

These rail motor coaches are used for local services and take the place of mixed steam trains on the light railways. At the beginning of 1933, they were running 11 430 km. (7 102 miles) a day, i.e. 38 % of the total mileage of the light railways, or 18.7 % of the total mileage of the Royal State Railways.

The rail motor coaches under trial or construction can be divided up as follows :

20 rail motor coaches with three pairs of wheels and 130-H.P. engines to be used for local service,

6 rail motor coaches with two bogies, more powerful vehicles intended for fast services.

The greater part of the rail motor coaches (both those in service and under construction) are built by Messrs. GANZ and fitted with Ganz-Jendrassik engines.

The Royal State Railways carried out comparative trials in 1929 with rail motor coaches of similar types, some fitted with Diesel engines, and the others with petrol engines of the same power. These trials proved the superiority of the Diesel very clearly, so that on most of the rail motor coaches the petrol engines are being replaced by Diesels. It has been calculated that the cost of replacing the engines will be covered in a few years by the saving in fuel.

Mechanical transmission with pneumatic control has been used even on the largest rail motor coaches.

All the rail motor coaches run in either direction and can haul one or several trailers, except the two-bogie Ganz coach with a 275-H.P. engine, which is on order and is known as a Sinobus or rail omnibus.

The heating of the rail motor coaches is by the motor exhaust gases, and that of the trailers by special oil-fired boilers.

The present tendencies are shown by the following types :

— Ganz rail motor coaches with two or three pairs of wheels, for stopping trains (91 in service, 20 under construction) ;

— Ganz rail motor coaches with two engines and two bogies for fast trains (two under construction) ;

— Ganz rail motor coaches with one engine and two bogies for fast trains (two under construction).

Ganz rail motor coach with three pairs of wheels (fig. 75).

Ganz Jendrassik Diesel engine, 130 H.P. at 1 350 r.p.m., 6 cylinders, fitted in the middle of the vehicle.

Radiators in the roof ;

Mechanical transmission with pneumatic control, Ganz system. Constant-mesh gear box fitted under the floor.

46 seats. Weight, 19.8 t. (19.5 Engl. tons).

Maximum speed : 60 km. (37.3 miles) an hour.

Fig. 75. — Six-wheeled GANZ rail motor coach.

Can haul three trailers.

The gradient climbing capabilities of this vehicle are shown in figure 76.

The operating cost of 22 Ganz rail motor coaches with two and three pairs of wheels, during the years 1932 and 1933, are given below (the cost is given in French francs (100 fr. = 22.40 pengoes).

Working costs of 22 rail motor coaches with two and three pairs of wheels and one 130-H.P. Ganz-Jendrassik engine.

	Total cost (frs.)	Working costs per km.	*per mile.*	
Train staff	297 701	0.3259	*0.5245*	
Fuel	319 218	0.4372	*0.7036*	
Lubricants	46 730			
Maintenance and current repairs	81 697	0.0895	*0.1440*	after a mileage of 107 600 km. (66 860 miles).
Exceptional repairs	40 731	0.3782	*0.6086*	
Total		1.2308 fr. per km.	*1.9807 fr. per mile.*	

Total annual mileage in commercial service . 913 939 km. *(567 905 miles).*

Ganz rail motor coach with two bogies and two engines (fig. 77).

Two Gand-Jendrassik Diesel engines developing 200 H.P. at 1 250 r.p.m., one engine on each bogie : the four pairs of wheels are driving wheels.

Radiators in the roof.

Mechanical transmission with Ganz pneumatic control.

Constant-mesh gear box, very shallow, fitted under the floor.

64 seats. Weight : 42 t. (41.3 Engl. tons).

Maximum speed: 90 km. (56 miles) an hour, with three trailers, and 60 km. (37.3 miles) with ten trailers.

Heating by engine cooling water, and by the exhaust gases.

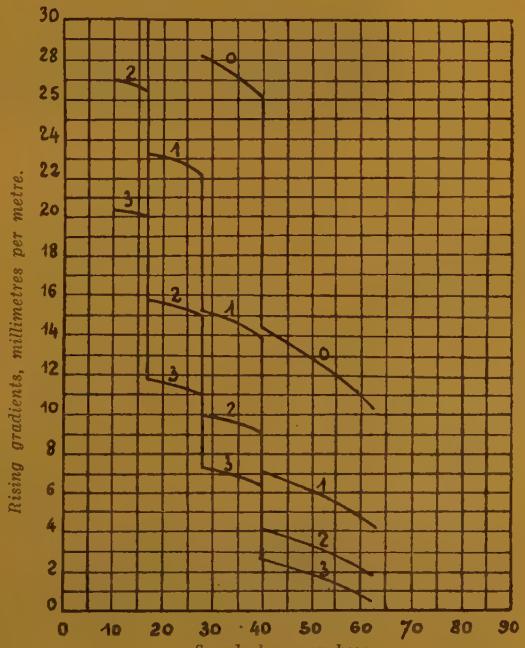
Knorr brake.

Ganz rail motor coach with two bogies and one engine.

Ganz engine of 275 H.P. at 1 200 r.p.m., 6 cylinders.

Radiator under the body, carried on the driving bogie.

Mechanical transmission with Ganz pneumatic control.



Curve 0, railcar alone.
Curve 1, railcar with 1 trailer.
Curve 2, railcar with 2 trailers.
Curve 3, railcar with 3 trailers.

Fig. 76. — Gradient climbing capability curves of GANZ six-wheeled railcar weighing 24.2 t. (23.8 Engl. tons).

Constant mesh gear box with 5 speeds. 75 seats. Weight : 30 t. (29.5 Engl. tons).

Maximum speed : 120 km. (75 miles) an hour.

Heating by engine cooling water.

Fig. 77. — GANZ rail motor coach with two bogies and two engines.

ROYAL HUNGARIAN STATE RAILWAYS

Transmission.		Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
Type.	Builders.								
In service.									
72 4-wheeled railcars of various designs with petrol engine.									
Mech.	Various.	55 to 75 (*34.2 to 46.6*)	4	7 to 21 (*6.9 to 20.7*)	Rev. Trailer.	29 to 50	Before 1930	22 000 to 250 000 (*13 670 to 155 350*).	Local
3 M.A.V. railcars with one 100-H.P. petrol engine.									
Mech.	National Automobil Gesellschaft.	60 (*37.3*)	8	35 (*34.4*)	Rev. Trailer.	73	Before 1930	220 000 to 300 000 (*136 700 to 186 000*).	Local

Transmission. Type.	Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
		2 railcars with one Diesel engine { *1 with Ganz engine.* *1 with Maybach engine.*							
mech. hydr.	Various.	60 *(37.3)*	8	30 and 40 *(29.5* and *39.4)*	Rev. Trailer.	80	1926	70 000 and 160 000 *(43 500* and *100 000).*	Local.
		14 railcars with one 130-H.P. Ganz Diesel engine.							
Mechanical transmission with pneumatic control, Ganz system.	Ganz.	55 to 75 *(34.2 to 46.6)*	4	20 *(19.7)*	Rev. Trailer.	46	1930 1932	50 000 *(31 000)*	Local.
		12 Ganz railcars with one 130-H.P. Ganz Diesel engine.							
	Ganz.	55 *(34.2)*	6	21 *(20.7)*	Rev. Trailer.	46	1932	60 000 *(37 300)*	Local.
		Under trial or construction.							
		*20 railcars with one 130-H.P. Ganz Diesel engine.**							
	Ganz.	60 *(37.3)*	6	20.2 *(19.9)*	Rev. Trailer.	46	...	...	Local.
		2 Ganz railcars with one 95-H.P. Ganz Diesel engine.							
	Ganz.	90 *(56)*	4	9.4 *(9.2)*	Not rev. No trail.	36	...	...	Express.
		*2 Ganz railcars with one 275-H.P. Ganz Diesel engine.**							
	Ganz.	120 *(75)*	8	30 *(29.5)*	Rev. No trail.	75	...	...	Express.
		*2 Ganz railcars with two 220-H.P. Ganz Diesel engines.**							
	Ganz.	90 *(56)*	8	42 *(41.3)*	Rev. Trailer.	64	...	...	Express.

* *Note.* — Railcars marked * have been described in the text.

Italy.

The Italian Railways had 14 rail motor coaches in service on the 1st January, 1934. Nine of them had petrol engines with mechanical transmission, and the five others Diesel engines with electrical transmission. 69 Fiat rail motor coaches with petrol engines were under trial or construction.

The Italian Railways have found the most difficult problem presented by rail motor coaches was not the technical problem but the question of operation. They therefore ordered rail motor coaches with petrol engines which had proved their reliability, with very simple mechanical transmission.

They also considered that passengers are attracted above all by high overall speeds. Their vehicles have been particularly well designed in this connection and the builders have tried to get rapid acceleration by all possible means. Fiat

uses the free wheel which, apart from the facility it gives in running down gradients with the engine declutched and idling, enables the gear to be changed without declutching which prevents loss of time when changing gear.

Breda uses the preselective gear box on the Wilson system.

The Italian rail motor coaches are also characterised by the attention paid to the comfort of the passengers and by their modern artistic decoration.

*Fiat rail motor coach with two bogies and one 120-*H.P. *Fiat petrol engine* (one in service, 59 under trial or construction).

Fiat petrol engine, 120 H.P. at 2 000 r.p.m. (6 cylinders).

Radiators at each end of the vehicle.

Fiat mechanical transmission with pneumatic control.

48 or 64 seats. Weight : 13 and 15 t. (12.8 and 14.8 Engl. tons).

Maximum speed : 110 km. (68.3 miles) an hour.

Pneumatic and hand-operated band brakes.

*Fiat rail motor coach with two bogies and two Fiat 120-*H.P. *petrol engines* (10 under trial and construction) (fig. 78).

Two 120-H.P. Fiat petrol engines, at 2 000 r.p.m., 6 cylinders.

Radiators at each end of the vehicle.

Fiat mechanical transmission with pneumatic control.

80 seats. Weight, 21.5 t. (21.2 Engl. tons).

Maximum speed : 140 km. (87 miles) an hour.

Pneumatic and hand-operated band brakes.

Heating by the exhaust gases.

*Breda rail motor coaches with two bogies and 120-*H.P. *petrol engine* (three vehicles in service).

Isouta Fraschini petrol engine, 120 H.P. at 2 500 r.p.m., 8 cylinders.

Radiators at each end.

Mechanical transmission.

Wilson 5-speed gear box.

72 seats. Weight, 12.5 t. (12.3 Engl. tons).

Hydraulic band brakes.

Fig. 78. — FIAT bogie rail motor coach. — The LITTORINA.

Piedmont.

The Piedmont General Tramway Company has twelve rail motor coaches with 160-cell Tudor accumulators in service. They are used for local services and are fitted with Westinghouse compressed air brakes.

ITALY

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
In service.									
3 Cemsa railcars with one 100 or 160-H.P. petrol engine.									
Mech.	C.E.M.S.A.	50 (*31*)	8	18 to 25 (*17.7 to 24.6*)	Rev. Twins. Trailer.	45 to 70	1927 1928 1929	50 000 to 100 000 (*31 000 to 62 000*)	Local.
4 Fiat railcars with one 180-H.P. Fiat Diesel engine.									
Electr.	Brown-Boveri.	55 (*34.2*)	8	44 (*43.3*)	Rev. Twins. Trailer.	30 to 38	1931	60 000 (*37 300*)	Local.
4 F.S. railcars with one 150-H.P. M.A.N. Diesel engine.									
Electr.	F.S.	60 (*37.3*)	8	34 (*33.5*)	Rev. Twins. Trailer.	45	1931	46 000 (*28 580*)	Local.
2 Fiat railcars with one 65-H.P. Fiat petrol engine.									
Mech.	Fiat.	58 (*36*)	4	7 (*6.9*)	Not rev. Trailer.	25	1932	60 000 (*37 300*)	Local.
*1 Fiat railcar with one 120-H.P. Fiat petrol engine.**									
Mech.	Fiat.	110 (*68.3*)	8	13 (*12.8*)	Rev. No trail.	48	1933	1 200 (*745*)	Express.
*3 Breda railcars with one 120-H.P. Isotta Fraschini petrol engine.**									
Mech.	Isotta Fraschini.	120 (*75*)	8	12.5 (*12.3*)	Rev. No trail.	72	1933	2 000 (*1 240*)	Express.
Under trial or construction.									
*11 Fiat railcars with one 120-H.P. Fiat petrol engine.**									
Mech.	Fiat.	110 (*68.3*)	8	13 (*12.8*)	Rev. No trail.	48	...	...	...
*48 Fiat railcars with one 120-H.P. Fiat petrol engine.**									
Mech.	Fiat.	100 (*62*)	8	15 (*14.8*)	Rev. No trail.	64	...	...	...
*10 Fiat railcars with two 120-H.P. Fiat petrol engines.**									
Mech.	Fiat.	140 (*87*)	8	21.5 (*21.2*)	Rev. No trail.	80	...	...	...

* *Note.* — Railcars marked * have been described in the text.

Norway.

The Norwegian Railways have 49 rail motor coaches of various types in service. They all have petrol engines and mechanical transmission. They are used for stopping services.

Four rail motor coaches with two pairs of wheels are being built at the present time, three of them with two 240-H.P. Buda petrol engines, and the other with two Mercedes-Benz Diesel engines, developing 300 H.P.

NORWAY

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
In service.									
21 railcars of various designs, with a petrol engine of about 100-H.P.									
Mech.	Various.	55 *(34.2)*	4	10 to 16 *(9.8 to 15.7)*	Not. rev. Trailer.	30 to 50	1924 to 1930	250 000 to 500 000 *(155 300 to 310 700)*	Local.
11 N.S.B. railcars with two 120 and 80-H.P. Buda petrol engines.									
Mech.	N.S.B.	65 *(40.4)*	4	14 *(13.8)*	Not. rev. Trailer.	52	1929 1930	250 000 *(155 350)*	Local.
8 A/S Strommens Verksted railcars with two petrol engines developing 250-H.P.									
Mech.	A/S Strommens Verksted.	70 *(43.5)*	4	18 *(17.7)*	Rev. Trailer.	50	1932	80 000 *(50 000)*	Local.
2 Deutsche Werke 2-bogie railcars with one 160-H.P. Mercedes petrol engine.									
Mech.	Deutsche Werke.	60 *(37.3)*	8	25 *(24.6)*	Rev. Trailer.	56	1923	260 000 *(161 600)*	Local.
3 A/S Skabo two-bogie railcars with two Buda petrol engines, developing 300-H.P.									
Mech.	T.A.G.	70 *(43.5)*	8	34.5 *(33.9)*	Rev. Trailer.	66	1932	84 808 *(52 700)*	Local.
4 A/S Strommens Verksted two-bogie railcars with two Buda petrol engines, developing 240-H.P.									
Mech.	N.S.B.	65 *(40.4)*	8	19 *(18.7)*	Rev. Trailer.	56	1932	48 500 *(30 140)*	Local.
Under trial or construction.									
3 A/S Strommens Verksted railcars with 2 Buda petrol engines, developing 240-H.P.									
Mech.	N.S.B.	70 *(43.5)*	4	17.4 *(17.1)*	Rev. Trailer.	50	...	...	...
1 A/S Strommens Verksted railcar with 2 Mercedes-Benz Diesel engines, developing 300-H.P.									
Mech.	N.S.B.	90 *(56)*	4	18 *(17.7)*	Rev. Trailer.	50	...	...	...

Poland.

The Polish Railways have eleven rail motor coaches in service. Ten of these are steam-driven and one has a petrol engine. At the present time they are designing a new rail motor coach.

POLAND

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
In service.									
9 Clayton steam railcars, 110-H.P.									
Mech.	Clayton.	70 (*43.5*)	8	42 (*41.3*)	Rev. Trailer.	70	1931-1933	28 000 (*17 400*)	Local.
1 Sentinel steam railcar, 120-H.P.									
Mech.	Sentinel.	60 (*37.3*)	8	31 (*30.5*)	Rev. Trailer.	63	1930	136 000 (*84 510*)	Local.
1 Austro-Daimler railcar with two 80-H.P. Daimler petrol engine.									
Hydr.	Voith.	100 (*62*)	8	19 (*18.7*)	Rev. Trailer.	60	1933	15 000 (*9 320*)	Express.

Portugal.

Messrs. Michelin are building 2 railcars with one 85-H.P. Panhard petrol engine for the Mosambique Colony; these coaches have six pairs of pneumatic-tyred wheels and provide 22 seats ; they can haul a four-wheeled 12-seater trailer with pneumatic tyres.

The railcar and its trailer are fitted with the Lockheed hydraulic brake.

PORTUGAL

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
Under construction for the Mosambique Colony.									
2 South African Railways and Harbours railcars with two 70-H.P. Hudson petrol engines.									
Mech.	Hudson.	64 (*40*)	6	13.6 (*13.4*)	Not. rev. No trail.	13	...	...	Local.
*2 « Michelin » railcars with one 85-H.P. Panhard petrol engine.**									
Mech.	Panhard.	85 (*52.8*)	12	6.2 (*6.1*)	Not. rev. 1 trailer.	22	...	...	Express.

* *Note.* — The railcar marked * is described in the text.

Sweden.

The Royal Swedish State Railways have ten rail motor coaches of various types. Eight are of an old type with a petrol or Diesel engine, and two have just been put into service on secondary lines. These latter vehicles are fitted with two 100-H.P. petrol engines with mechanical transmission. They are carried on four pairs of wheels, weigh, 34 t. (33.5 Engl. tons) when empty, and can run at a maximum speed of 70 km. (43.5 miles) an hour on the level. There are seats for 54 passengers.

The Bergslagen Railways have had a four-wheeled Nohab rail motor coach in service since 1933. This vehicle has a 90-H.P. Maybach Diesel engine (6 cylinders) with mechanical transmission. The engine is elastically suspended at three points and well isolated from the body so as to prevent noise and vibration.

This vehicle has 40 seats and weighs 7.4 t. (7.3 Engl. tons) empty. It can run at 75 km. (46.6 miles) an hour on the level. It can only run in one direction and cannot haul a trailer.

The Halmstad Nässjo Railway has D. E. V. A. Diesel-electric rail motor coaches dating from 1914-24. Several types of rail motor coaches (Austro-Daimler, A. S. E. A., etc.) and some rail omnibuses are under construction.

The Vastergötland Railway has a stock of rail motor coaches which consists of 5 petrol-engined vehicles which can all run in either direction and can haul trailers. All these vehicles have mechanical transmission with pneumatic control.

Switzerland.

The Federal Railways have two Diesel-electric rail motor coaches in service, one of which has a 250-H.P. engine and the other a 420-H.P. engine. They weigh about 60 t. (59 Engl. tons).

They have under construction, at the Winterthur Locomotive and Engine Works, two Diesel rail coaches designed as follows :

300-H.P. Sulzer Diesel engine, 1 200 r. p. m. (6 cylinders).

Winterthur mechanical transmission worked by oil under pressure.

Two driving compartments.

70 seats. Weight : 29.5 t. (29 Engl. tons).

Maximum speed : 125 km. (77.7 miles) an hour.

Compressed air brakes.

Heating by hot air.

Czechoslovakia.

The Czechoslovakian Railways have 248 rail motor coaches in service at the present time, and 162 are under trial and construction. These can be classified into two distinct classes :

1. Rail omnibuses, which are light vehicles, of no great speed, with low-power engines, intended for secondary lines.

2. Faster and heavier rail motor coaches fitted with high-power engines for main line services.

1. *Rail omnibuses.*

The first types of such vehicles, put into service in 1927, do not haul trailers and cannot be reversed. The Czechoslovakian Railways soon discovered the drawbacks of this type of vehicle, and in 1928 they designed new rail omnibuses of higher power which could haul one or two trailers. These vehicles and their trailers were fitted with a central buffer which had the drawback of making it impossible to haul carriages and wagons of the usual railway type. Finally, in 1930, they put into service rail omnibuses fitted with the usual type of buffing and draw gear.

The rail omnibuses with petrol engines

use Czechoslovakian national fuel or dynalcohol which is made up of : 70 % petrol, 26 % dehydrated alcohol, and 4 % benzol.

The rail omnibuses are heated by the exhaust gases, while the trailers are heated by a special coke stove.

Tatra four-wheeled rail motor coach (69 vehicles in service, 40 under construction).

115-H.P. Tatra petrol engine, 1 200 r.p.m., 6 cylinders, carried in the middle of the vehicle.

Radiators under the floor.

Mechanical transmission.

The vehicle can run in either direction, the driver being in a raised central compartment.

42 seats. Weight : 12.6 t. (12.4 Engl. tons).

Maximum speed : 60 km. (37.3 miles) an hour.

Skoda four-wheeled rail motor coach (25 vehicles in service, 27 under construction).

120-H.P. Skoda petrol engine, 1 600 r.p.m., 6 cylinders carried in the middle of the vehicle under the floor, on the special sub-frame bolted to the main frame.

Mechanical transmission with pneumatic control (Skoda system).

Can run in either direction; driving compartment at each end.

38 seats. Weight : 13.6 t. (13.4 Engl. tons).

Maximum speed : 65 km. (40.4 miles) an hour.

Trailers :

Two types :

1. 36 seats. Weight : 8.2 t. (8.1 Engl. tons). Luggage compartment measuring 6.72 m² (72 sq. feet).

2. 46 seats. Weight : 8 t. (7.9 Engl. tons). No luggage compartment.

2. *Rail motor coaches.*

The rail motor coaches for main line services have bogies and can all run in either direction. As a rule they have Diesel engines and electrical transmission.

The brakes are of the Knorr type improved by Skoda. Electro-magnetic brakes are not used.

Ceskomoravska - Kolben - Danek eight-wheeled rail motor coach (two in service, eight under construction or trial).

380-H.P. C. K. D. Hesselman Diesel engine, 1 000 r.p.m., 6 cylinders.

Radiators in the roof.

C. K. D. electrical transmission.

The leading bogie carries the Diesel engine and the generator, and the trailing bogie the two traction motors (fig. 52).

Can haul one or two carriages.

Maximum speed, rail motor coach by itself, 100 km. (62 miles) an hour.

64 seats. Weight : 47 t. (46.3 Engl. tons).

Fuel oil consumption : 7 to 8 gr. per tkm. (0.398 oz. per Engl. ton-mile).

Brno-Kralovopolska rail motor coach on four pairs of wheels (two in service, two under construction or trial).

Two 160-H.P. Brno-Kralovopolska Diesel engines, 1 300 r.p.m.

8 cylinders arranged in V.

Radiators in the roof.

Brown-Boveri electric transmission.

Two identical bogies each carrying one Diesel engine, one generator and one traction motor (fig. 54).

80 seats. Weight : 42 t. (41.3 Engl. tons).

Maximum speed : 100 km. (62 miles) an hour.

Can haul one or two trailers.

The Czechoslovakian Railways, basing their calculations on the results obtained up to the present, estimate as follows the working costs of steam traction and Diesel-electric traction, in crowns.

	Steam traction.		Diesel-electric traction.	
	Per train-km.	*Per train-mile.*	Per train-km.	*Per train-mile.*
Amortisation	3.21	*(5.16)*	1.83	*(2.94)*
Maintenance	2.19	*(3.52)*	0.90	*(1.45)*
Staff	2.20	*(3.54)*	0.51	*(0.82)*
Fuel	1.52	*(2.45)*	0.77	*(1.24)*
Lubricant	0.16	*(0.26)*	0.35	*(0.56)*
Total	9.28	*(14.93)*	4.36	*(7.01)*
i. e. per 100 seats	3.10	*(4.99)*	3.11	*(5.00)*

These figures were based on 300 seats per steam train and 140 seats in the case of a rail motor coach with a trailer.

CZECHOSLOVAKIA

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order. t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
In service.									
89 petrol railcars of various designs, with mechanical transmission.									
Mech.	Various.	45 to 80 *(28 to 50)*	14 eight-wh. 75 four-wh.	7 to 34 *(6.9 to 33.5)*	12 not rev. Trailer. 77 rev. Trailer.	30 to 86	Before 1930	141 000 to 420 000 *(87 600 to 261 000)*	Local
18 petrol railcars of various designs with electric transmission.									
Electr.	Various.	45 to 60 *(28 to 37.3)*	3 eight-wh. 15 four-wh.	13 to 42 *(12.8 to 41.3)*	Rev. Trailer.	34 to 82	1929 1930 1931	114 000 to 180 000 *(70 800 to 111 850)*	Local
2 Severoceska-Vozovka railcars with one 150-H.P. M.A.N. Diesel engine.									
Electr.	Brown-Boveri.	70 *(43.5)*	4	28.6 *(28.1)*	Rev. Trailer.	44	1931	86 800 *(53 940)*	Local
8 Skoda railcars with one 100-H.P. Diesel engine.									
Electr.	Skoda.	50 *(31)*	4	19.5 *(19.2)*	Rev. Trailer.	50	1932	44 241 *(27 490)*	Local

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
		28 Moravsko-Slezskà railcars with one 100-H.P. Tatra petrol engine.							
Electr.	Gebus.	50 *(31)*	4	18.7 *(18.4)*	Rev. Trailer.	48	1930 1932	129 000 *(80 160)*	Local.
		*69 Tatra railcars with one 100-H.P. Tatra petrol engine.**							
Mech.	Tatra.	50 *(31)*	4	12.5 *(12.3)*	Rev. Trailer.	42	1931 1932	75 000 *(46 600)*	Local.
		*25 Skoda railcars with one 100-H.P. Skoda petrol engine.**							
Mech.	Skoda.	50 *(31)*	4	13 *(12.8)*	Rev. Trailer.	38	1932 1933	40 800 *(25 350)*	Local.
		2 Brno-Kralovopolska railcars : *One with 2 Brno-Krolovopolska petrol engines developing 120-H.P.* *One with 2 Brno-Kralovopolska Diesel engines developing 120-H.P.*							
Electr.	Brown-Boveri.	54 *(33.5)*	8	53 *(52.2)*	Rev. Trailer.	54	1933	35 246 *(21 900)*	Express.
		2 Tatra railcars with two 100-H.P. Tatra petrol engines.							
Mech.	Tatra.	80 *(50)*	8	39 *(38.4)*	Rev. Trailer.	68	1932	114 156 *(70 935)*	Express.
		1 Skoda railcar with one 300-H.P. Skoda Diesel engine.							
Electr.	Skoda.	80 *(50)*	8	50 *(49.2)*	Rev. Trailer.	53	1932	44 369 *(27 570)*	Local.
		*2 Ceskomoravska-Kolben-Danek railcars with one 300-H.P. C.K.D. engine.**							
Electr.	Westing-house C.K.D.	90 *(56)*	8	53 *(52.2)*	Rev. Trailer.	54	1933	35 246 *(21 900)*	Express.
		*2 Brno-Kralovopolska railcars with two 160-H.P. Brno-Kralovopolska Diesel engines.**							
Electr.	Brown-Boveri.	80 *(50)*	8	44.5 *(43.8)*	Rev. Trailer.	75	1933	12 803 *(7 955)*	Express.
		Under trial or construction.							
		*27 Skoda railcars with one 120-H.P. Skoda petrol engine.**							
Mech.	Skoda.	65 *(40.4)*	4	13.6 *(13.4)*	Rev. Trailer.	38	...	...	Local.
		*10 Tatra railcars with one 115-H.P. Tatra petrol engine.**							
Mech.	Tatra.	45 *(28)*	4	12.7 *(12.5)*	Rev. Trailer.	42	...	...	Local.

* *Note.* — Railcars marked * have been described in the text.

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels.	Weight empty, in working order, t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
*30 Tatra railcars with one 115-H.P. Tatra petrol engine.**									
Mech.	Tatra.	60 *(37.3)*	4	12.3 *(12.1)*	Rev. Trailer.	42	...	...	Local.
10 Tatra railcars with one 115-H.P. Tatra Diesel engine.									
Mech.	Tatra.	60 *(37.3)*	4	12.5 *(12.3)*	Rev. Trailer.	42	...	...	Local.
20 Moravsko-Slezskà railcars with one 120-H.P. Tatra petrol engine.									
Electr.	C.K.D.	60 *(37.3)*	4	17.4 *(17.1)*	Rev. Trailer.	44	...	...	Local.
10 Moravsko-Slezskà railcars with one 125-H.P. Tatra Diesel engine.									
Electr.	C.K.D.	60 *(37.3)*	4	18 *(17.7)*	Rev. Trailer.	44	...	...	Local.
21 Skoda railcars with one 120-H.P. Skoda Diesel engine.									
Electr.	Skoda.	60 *(37.3)*	4	17.4 *(17.1)*	Rev. Trailer.	52	...	...	Local.
19 Skoda railcars C.K.D. with one 130-H.P. C.K.D. Diesel engine.									
Electr.	C.K.D.	70 *(43.5)*	4	19 *(18.7)*	Rev. Trailer.	52	...	...	Expres
2 Brno-Kralovopolska railcars with two 160-H.P. Brno-Kralovopolska Diesel engines.									
Electr.	Brown-Boveri.	100 *(62)*	8	42 *(41.3)*	Rev. Trailer.	80	...	...	Expres
5 Skoda railcars with one 350-H.P. Skoda Diesel engine.									
Electr.	Skoda	100 *(62)*	8	47 *(46.3)*	Rev. Trailer.	74	...	...	Expres
*8 C.K.D. railcars with one 350-H.P. C.K.D. Hesselman Diesel engine.**									
Electr.	C.K.D.	100 *(62)*	8	47 *(46.3)*	Rev. Trailer.	64	...	...	Expres

* *Note.* — Railcars marked * have been described in the text.

Turkey.

The Turkish Railways put into service, in February 1933, three Esslingen steam rail motor coaches, designed as follows :

— Boiler : water tubes, 25 kgr./cm² (355 lb. per sq. inch).
— Motion carried on a truck.
— A single driving axle.
— Poppet valve gear with Walschaerts link motion.

— Semi-automatic firing, so that the vehicle can be driven by a single man.

— The leading end of the body is carried on the back of the motor unit, and its other end on a carrying bogie.

— The vehicle cannot be reversed.

— It can haul one or several trailers.

— 56 seats. Weight : 53 t. (52.2 Engl. tons).

— Maximum speed : 100 km. (62 miles) an hour.

— Kunze-Knorr compressed air brake.

TURKEY

Transmission. Type.	Transmission. Builders.	Maximum speed on the level km. (*miles*).	Number of wheels	Weight empty, in working order. t. (*Engl. tons*).	Reversibility. Twin coaches or multiple-unit. Trailer.	Number of seats including tip-up.	Year put into service.	Distance run per vehicle, km. (*miles*).	Kind of service.
In service.									
3 Esslingen railcars with one 450-H.P. steam engine.									
...	...	100 *(62)*	8	53 *(52.2)*	Not rev. Can be coupl. up. Trailer.	56	1933	40 000 *(25 000)*	Fast local.
Under construction.									
*6 Skoda railcars with one 75-H.P. petrol engine.**									
Mech.	Skoda	60 *(37.3)*	4	10.4 *(10.2)*	Rev. No trail.	32	...	...	Local.

* *Note.* — Railcars marked * have been described in the text.

Jugoslavia.

The Jugoslav State Railways have two Ganz four-wheeled rail motor coaches in service. These are fitted with one Ganz petrol engine developing 90 H.P. at 1 150 r.p.m.

The engine is carried in the middle of the vehicle and the transmission is mechanical with pneumatic control.

These vehicles can run in either direction and can haul trailers. They have 46 seats, weigh 17.5 t. (17.2 Engl. tons) and are used on stopping services.

Their total mileage since being put into service is 454 000 km. (282 100 miles).

At the present time, the Jugoslav State Railways have not any rail motor coaches on order, but the experience obtained in operating the above mentioned vehicles has decided them to select in the future faster rail motor coaches, of light construction, with more powerful engines.

NEW BOOKS AND PUBLICATIONS.

[385. (02 & 656. 2 (02]

LAMALLE (U.), Ingénieur Civil des Mines, A. I. Lg., Assistant General Manager of the Belgian National Railways Company. — **Cours d'exploitation des chemins de fer.** Tome I : **Exploitation commerciale,** 3e édition. (*Railway operating course.* Vol. I : *Commercial operating,* 3rd edition). — 1 vol. (10 × 8 inches) of 202 pages with 92 figures and many tables. — 1934, Louvain : Librairie Universitaire, rue de la Monnaie, 10; Paris, Dunod, rue Bonaparte, 92. — Price (60 francs).

The railway situation has altered since the second edition of Mr. Lamalle's commercial operating course was published: a review appeared in the June, 1929, *Bulletin.* The increasing competition of other forms of transport has been added to the effects of the more serious economic crisis. The railways reacted by measures lying within the limitations of the existing regulations governing them, and by calling for and obtaining modifications thereof. New developments resulting from the present difficulties are mentioned throughout the book.

In Chapter I, on legislation applicable to transport by rail, containing an analysis of the 1891 Belgian law, the author explains the circumstances under which this law was passed and shows that if justifiable when the railway had a monopoly, as in fact it then had, the conditions today are quite different.

Chapter II deals with *rates* and in turn with : the conditions under which they apply, the bases on which the rates are built up, and the preparation and classification of rates.

The book gives a concrete and remarkable example, the Belgian rates, the simplicity and flexibility of which are brought out very clearly. In the same chapter, under the heading « classification of rates », the author shows in detail the economics and value of special and international rates.

The general passenger rates in Belgium are proportional. The author indicates the circumstances under which differential rates are justifiable. Some of the special rates may be criticised from a railway point of view. Season ticket rates are differential. Workmen's ticket rates apply to an important volume of traffic; their influence on the economic and social life of the community is discussed in brief terms.

Chapter IV entitled; *The Utility of railways,* is specially interesting on account of its originality. It shows how the railway field of activity can be recognised and worked.

The value of diversifying the rates, which has been progressively adopted in the Belgian rates, is brought out. Detailed information on this subject is given in chapter II.

Chapter V, on *Working costs,* defines what is meant by average total cost, industrial cost, and partial cost. The method of calculating the average total cost per passenger-kilometre and per tonne-kilometre is given. The difficulty in allocating the proportion of the operating and financial charges not directly applicable is brought out and the bases of a suggested division discussed.

The 1932 operating results of the Belgian National Railways Company are used as representing an actual example of the application of the method. The comparison of the costs of recent years, one to the others, and with those of the years prior to 1914, reveals the incidence of the deep changes in the economic position and the operating methods.

Chapter VI, *Operating results*, brings the general operating statistics together so that the financial position and the operating results of a given year can be appreciated. The exact meaning of the operating coefficient and its value as a criterion of good management are discussed, and the possible variation in the capital invested and the movement of the receipts is also dealt with. Here again numerical data borrowed from the latest statistics of the Belgian National Railways Company are used to support the theoretical argument by actual and up-to-date facts.

Chapter VII, a new one, of much present interest, deals with the *Effect of road competition on railway rates.*

The author shows how the method of basing rates on the value of the goods, entirely justified in the general interest, has been upset by road competition, and points out that, to protect their traffic, the railways have been forced to abandon the principle in force in the days of their monopoly.

He then contrasts the railway, bound by many legal prescriptions, with its competitor with complete freedom as regards rates, and ends by hoping the necessary legal reform will be introduced in the near future.

E. M.

[313 : 385 (44) & 385. 113 (.44)]

GODFERNAUX (R.), Engineer, Member of the Committee for Public Works in the Colonies, France; Director of the *Revue Générale des Chemins de fer.* — **Les Grands Réseaux de Chemins de fer français,** année 1933 (*The French Main Line Railways, 1933*). — A pocket book (4 1/2 × 6 3/4 inches) of 40 pages. — 1934, Paris, Dunod, 92, rue Bonaparte. (Price : 5 French francs.)

As in previous years, the author, in reviewing the principal happenings which have marked the working of the French Main Line Companies, publishes the main statistical tables giving particulars of the operating results and the movement of the traffics. These tables show that, in spite of the very great economies made in the operating costs, the receipts have been still lower than in 1932, and the final financial results again show a serious deficit (nearly four thousand million francs).

Although the position has not improved financially in this respect, certain reforms were introduced in 1933 with, it would seem, happy results. The public authorities have modified the agreement under which the Main Line Companies have been worked since the Ist January, 1921, and several decrees have been put into force to make the regulations controlling the companies more flexible.

The author gives the main dispositions of the amendement to the 1921 agreement. The control by the State is strengthened ; the Management Committee has had its powers extended so as to be able to ensure greater co-ordination in the working of the companies ; the financial relationship between the State and the railways has been changed, a fresh formula for the management premium being applied, and the amortisation being on a different scale (the rolling stock is paid off more quickly, and in the event of the concession being bought back or ending, the allowance for taking over rolling stock purchased under certain conditions has been abolished as from 1933).

The decree of the 30th December, 1933, changes the procedure which has to be followed when introducing new carriage charges, and allows the companies to impose scales of charges having maximum and minimum rates.

The decree of the 19th January, 1934,

authorises the Minister to change the legal prescriptions, and the conditions of the agreements, with a view to reducing operating costs. Among such changes are those dealing with rail motor coach services, which are being extended very quickly.

Amongst other decrees, that of the 1st November, 1933, reduces the tax on passenger tickets to 12 % (instead of 32.5 % as previously).

With regard to co-ordination between rail and road, the author notes with pleasure that great progress has been made. The Government issued the decree of the 19th April, 1934, based on the conclusions formulated by the National Economics Council to co-ordinate rail and road transport. The description of the way the new organisation has been constituted will be read with interest.

At the same time, as he gives particulars of the measures introduced by the public authorities, most of which were called for by the railways, the author underlines the efforts made by the companies in various directions, such as cheaper operation, general acceleration of services, and adaptation of their methods to present-day traffic demands.

E. M.

[656. 1. & 656. 2]

CONFEDERAZIONE NAZIONALE FASCISTA DELLE IMPRESE DI COMMUNICAZIONI INTERNE. — **I problemi attuali dei trasporti terrestri** (*Present-day inland transport problems*). — A publication issued by the National Fascist Confederation of Interior Transport Undertakings. — One vol. (8 × 6 inches) of 150 pages. — 1933, Rome, Confederazione Nazionale Fascista delle Imprese di Communicazioni Interne, 149, Via Quattro Fontane.

The National Fascist Confederation of Interior Transport Undertakings has collected in this work up-to-date information on the problems with which its members are most closely concerned. (This Confederation is an union of the light railway companies and the road motor transport firms). Its object is to strengthen the idea that co-ordination of the different methods of transport must be developed.

The information is given in the form of speeches, opinions, and papers by men whose position or office gives them particular authority. The speeches are chiefly those made in Parliament during the budget discussions, the documents attached to proposed decrees or suggested finance laws, and papers given at meetings of transport specialists.

The first part headed : *Vital need of the companies holding concessions*, deals with the relations between the State and the companies, the reasons why the terms of the concessions require amendment and the effect of recently introduced changes. The circumstances which favoured the growth of competition and the shortcomings of the legislation are examined and the necessity for profoundly altering the present arrangements is made clear.

The second part is headed: *Financial and legislative aspects of the relations between the railway and the road motor.* The respective positions of the two methods of transport, the effect of competition on the decline in rail traffic, the opinions expressed abroad and at Congresses of specialists in the matter (especially at the Cairo Congress), and the steps taken in different countries, are discussed.

One chapter deals in particular with rates and the comparative cost of transport by rail and by road motor vehicle. Amongst the methods suggested for bettering the situation may be mentioned : containers and rail motor coaches.

The dominating idea is the necessity

for co-ordinating the two methods of transport, a task which involves the intervention of the State. H. E. Ciano, Minister of Communications, developed the idea in two speeches in Parliament, in which he outlined the general principles adopted by the Government and announced legislation in the near future for regulating the transport of goods by road motor vehicles.

E. M.

[385 (02 (.4)]

VEREIN MITTELEUROPAISCHER EISENBAHNVERWALTUNGEN. — **Stationsverzeichnis der Eisenbahnen Europas** (*früher : Dr. Kochs Stationsverzeichnis*). — **List of European railway stations** (*formerly Dr. Koch's List of Stations*). — One volume (17 × 7 inches) of XXII + 1 004 pages with 5 coloured inset maps. — 1934, Berlin-Wilmersdorf; Von Barthol & Co., editor, 3, Mehlitzstrasse. (Price : 28 Rm.)

This jubilee edition, it being the 50th of the list published periodically, has been prepared, from official data, by Mr. A. Nether, General Secretary of the Union of Central European Railway Administrations.

It includes not only countries the railways of which have remained in the *Verein*, known until 1932 as the Union of German Railway Administrations, but also the other countries of Europe, with the exception of England and Ireland.

In the first part, the names of the stations are given in geographical order, i.e. as they occur along the line, with the cumulative distances. Conventional signs refer to the kinds of traffic handled, service equipment such as loading ramps, weigh-bridges, etc. Each station has a reference number, and the numbers form a continuous series for each railway system.

In the second part, the stations are arranged in alphabetical order, together with their reference number and the page of the first part, as well as the railway. Certain data are repeated from the first part, while others complete the information given, such as the gauge. A special sign marks those stations to which the international agreement on the transport of goods by rail applies.

Other useful information is given in one part or the other, such as : the addresses of the headquarters of the railways and of the various departments ; the political divisions in which the stations, the transit stations between railways, and the frontier stations are located, membership of the Verein, etc.

An interesting innovation is concerned with railway-operated road motor transport. In an *appendix* there is a list of places not linked up by railway, selected as auxiliary depots for motor transport services, with their distances from the railway stations which serve as a junction or transit place.

This special edition is illustrated by a number of maps giving a complete idea of the geographical situation and the political divisions of the countries concerned, to facilitate the use of the book as a work of reference.

E. M.

585. (06. 111 |

OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

International Railway Congress Association

Meeting of the Permanent Commission, held on the 7th July, 1934.

The Permanent Commission of the International Railway Congress Association met on the 7th July last in the Assembly room of the Belgian National Railways Company's Head Offices at Brussels.

* * *

Mr. RULOT, *President*, was in the chair. On opening the meeting, he paid a tribute to the memory of four members of the Permanent Commission, whose death occurred since the previous meeting on the 29th July, 1933 :

Lord CHURCHILL, Chairman of the Board of Directors, Great Western Railway, President of the London Session, 1925, and life member;

Sir Frederic PALMER, who represented the Government of India;

Youssef RISGALLAH BEY, General Secretary of the Cairo Session, in 1933;

M. MOLLE, Technical Secretary to the General Manager of the Belgian National Railways Company.

He then recalled that Mr. GRIOLET, former Vice-President of the Board of Directors of the French Nord Railway and last survivor of the promoters of the Association, recently passed away in his 92nd year.

The Meeting then elected the following Gentlemen as members of the Permanent Commission :

Mr. LE BESNERAIS, Manager, Traffic and Working, Nord Railway, France,

Mr. BOUTET, General Manager, Railways and Roads, Ministry of Public Works, France,

Mr. MUGNIOT, General Manager, Paris-Lyons and Mediterranean Railway,

Mr. Otto SENN, Ministerial Councillor, General Manager of the Austrian Federal Railways,

Mr. WANG, Representative of the Chinese Ministry of Railways in London,

Mr. KAWAI, Manager of the Berlin Office of the Japanese Government Railways,

Mr. BAUER, Manager, Alsace-Lorraine Railways,

Mr. RAMALLO, Director of the Institute for Transport Economics, Ministry of Public Works, Argentina, and

Mr. DJOURITCHITCH, Assistant Minister

of Communications, Kingdom of Jugoslavia,

who respectively take the place of Messrs. JAVARY, GRIMPRET, MARGOT, DE SAMARJAY, WOO, OGURA, FONTANEILLES, CASTELLO and KNEJEVITCH, who resigned (Art. 6 of the Rules and Regulations).

Were also elected as members of the Permanent Commission :

Mr. G. JADOT, Manager, Financial Department, Belgian National Railways Company,

Sir Hugh HANNAY, Agent, East Indian Railway, and

Mr. E. THOMAS, Deputy General Manager, Egyptian State Railways,

who replace Mr. MOLLE, Sir Frederick PALMER and Youssef RISGALLAH BEY respectively.

A new mandate of member of the Permanent Commission was also conferred on Mr. KITTEL, Reichsbahndirektor, Mitglied der Hauptverwaltung, German State Railways.

The Meeting finally elected Mr. LE BESNERAIS, already named, as member of the Executive Committee of the Association, as successor to Mr. JAVARY. The Meeting also noted with pleasure that Sir Evelyn CECIL, Director of the Southern Railway and member of the Executive Committee of the Association, had been made a Peer of the Realm, under the name of Lord ROCKLEY.

* * *

The statement of receipts and expenditure for the year 1933 was approved by the Meeting; the provisional budget drawn up for 1934 showed that the financial position of the Association was quite satisfactory.

The rate of the variable part of the yearly contribution, which was 0.12 gold-franc per kilometre of line for the year 1934, was brought down to 0.10 gold-franc for 1935, the maximum laid down by the Rules and Regulations being 0.20 gold-franc.

* * *

Mr. P. BARRIOL, General Secretary of the Institute of Statistics, at the Paris University, and Sir Henry FOWLER, member of the Permanent Commission, who where appointed, by the Plenary Meeting at the Cairo Session in 1933, as auditors for the accounts of the financial years 1931-1932 and 1933 (administration accounts of the 12th Session), read their report.

* * *

The Meeting was then informed of the progress of the work in connection with the investigation into the two questions of immediate interest named below (decision of the Permanent Commission, taken on the 29th July, 1933) :

1. — Rail motor cars from the point of view of their construction: Types of engine. Forms of transmission. Body design. Lighting, heating and ventilation. Speed characteristics and carrying capacity, etc.

2. — The World Crisis and Railways and the effects of the crisis on railway working ; measures taken to lessen the effects of the crisis; competition or collaboration between railway and road transport; a forecast of the future; new ideas as to passenger transport, such as light quick trains between large towns and between large and small towns, running at regular intervals.

The persons entrusted with the task of drawing up reports on these questions are :

For question I (rail motor cars) :

a) *European Continent :*

Messrs. :

L. DUMAS, Ingénieur en chef adoint du

Matériel et de la Traction, French Nord Railway, and

J. Levy, Chef adjoint du Matériel et de la Traction, French State Railways;

b) *All other countries :*

Mr. Wanamaker, Electrical Engineer, Chicago, Rock Island and Pacific Railway Company.

For question II (The world crisis and its effects) :

a) *Main-line Systems belonging to the International Railway Union (U.I.C.) :*

Mr. von Beck, Reichsbahndirektor (Germany), and

Dr. Cottier, General Secretary, Swiss Federal Railways;

b) *Other main-line railways :*

Mr. Ashton Davies, Chief Commercial Manager, London Midland and Scottish Railway;

c) *Secondary railways :*

Mr. La Valle, Ingénieur, Inspecteur en Chef de vigilance à l'Inspectorat Général des Chemins de fer, Tramways et Automobiles, Italy,

Mr. Mellini, Ingénieur, Inspecteur supérieur de vigilance, Same Administration, and

Mr. Valcke, Traffic Manager, Belgian National Light Railways Company.

This work is proceeding as rapidly as possible; the report drawn up by Mr. Ashton Davies had already been published, and the others were well in hand.

* * *

The following alterations took place in the Membership of the Association, since the last Meeting :

RAILWAY ADMINISTRATIONS.

The Antioquia Railway (Colombia) has expressed a desire to join the Association.

On the other hand, the following Administrations have resigned their membership, the reasons given being the difficult financial position and the need for economies. Most of these Systems are of minor importance :

	Km.	Miles.
Bozanti-Alep Railway and Extensions (gone into liquidation on June 30th, 1933, and partly taken over by the Turkish State Railways who are members of the Association) .	744	*462*
Chemins de fer Départementaux du Tarn (bought up by the « Departement »)	180	*112*
Lehigh and New England Railroad	349	*217*
Federated Malay States Railways	1 792	*1 113*
Ferrovie del Ticino (being wound up)	151	*94*
Chemin de fer de Dakar à St-Louis (taken over by the Railways of French West Africa)	392	*244*
Chemin de fer de la Provence	463	*288*
Società Emiliana de Ferrovie, Tranvie e Automobili.	120	*75*
Uppsala Norrland Railway (taken over by the Swedish State Railways, members of the Association) .	505	*314*
Great Southern of Spain Railway	168	*104*
New York Central Railroad.	10 402	*6 464*

Finally, the Metropolitan Railway and the Underground Electric Railways Company of London have been amalgamated and taken over by the London Passenger Transport Board, a member of the Association.

At present, the Association is made up of 202 Administrations working together 522 126 km. (324 440 miles).

The Meeting was then informed of the decision recently taken by the Executive Committee, to publish each month in the three editions of the *Bulletin of the Association,* an article on the important question of the competition to which railways are subjected by other methods of transport (roads, waterways, airways).

These articles contain the information supplied by the affiliated Railway Administrations in connection with the legal and other measures taken by them in order to fight this competition.

The members present marked their approval.

* * *

The Executive Committee informed the Meeting that, in order to encourage personalities of the railway world to write technical and other articles which may prove of interest to the readers of the monthly *Bulletin,* they had decided that, in the future, these articles will be paid for at a markedly increased rate (authors fees), this decision applying only to original articles, i.e. which have not been published in any other paper.

* * *

Finally, the Meeting was acquainted with the steps the Executive Committee intends to take in connection with the organisation of the enlarged Meeting of the Permanent Commission, to be held in 1935 in Brussels, in order to examine and discuss the reports presented on the two questions of immediate interest mentioned above. It was decided, in principle, that this Meeting would coincide with certain ceremonies and festivities which the Belgian National Railways Company will organise in commemoration of the Centenary of the foundation of the railways in Belgium; it was also noted that the International Railway Congress Association will be 50 years old in 1935.

The Executive Committee obtained, from the Permanent Commission, full authority to carry out these proposed arrangements.

* * *

After the Meeting, and by courtesy of the Belgian National Railways Company, the members of the Permanent Commission made a trip from Brussels to Ghent and back on the new fast 410-H.P. twin-unit railcar recently put into service by that Administration.

P. Ghilain,
General Secretary.

N. Rulot,
President.

List of Members of the Permanent Commission

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(7th July, 1934).

President :

N. **Rulot** (3), directeur général de la Société Nationale des chemins de fer belges; rue du Progrès, 74, Brussels;

Vice-Presidents :

C. **Colson** (2), membre de l'Institut, inspecteur général des ponts et chaussées, vice-président honoraire du Conseil d'Etat de France, membre du Conseil supérieur des chemins de fer de France; rue de Laplanche, 2, Paris;

U. **Lamalle** (2), directeur général adjoint, directeur de l'exploitation à la Société Nationale des Chemins de fer belges; rue de Louvain, 17, Brussels.

Members of the Executive Committee :

R. **Le Besnerais** (1), directeur de l'exploitation de la Compagnie du Chemin de fer du Nord français; rue de Dunkerque, 18, Paris;

The Right Hon. Lord **Rockley** (1), P. C., G. B. E., director, Southern Railway; 2, Cadogan Square, London, S. W. 1;

D. **Vickers** (3), director, London Midland & Scottish Railway; Chapel House, Charles Street, Berkeley Square, London, W. 1.

Ex-presidents of sessions, members ex-officio :

J. **Gaytan de Ayala***, ancien président du Conseil des travaux publics d'Espagne; Villa Ulialde, San Sebastian;

H. E. Ibrahim Fahmy **Kerim** Pasha, Minister of Communications of Egypt; Cairo.

Members :

R. H. **Aishton** (3), president, American Railway Association; 30, Vesey Street, New York;

W. W. **Atterbury** (1), president, Pennsylvania Railroad Company; Broad Street Station, Philadelphia, Pa.;

H. **Bauer** (2), directeur des Chemins de fer d'Alsace et de Lorraine; 3, boulevard du Président Wilson, Strasbourg;

F. **Besser** (1), Ministerialrat, Reichsverkehrsministerium; Wilhelmstrasse, 80, Berlin, W. 8;

L. **Bochkoff** (2), ingénieur, directeur général des chemins de fer de l'Etat bulgare: Sofia;

Boutet (2), conseiller d'Etat, directeur général des chemins de fer et des routes au Ministère des travaux publics; 244, boulevard St-Germain, Paris;

J. **Castiau** (2), secrétaire général du Ministère des Transports de Belgique; rue de la Charité, 25, Brussels;

H. E. Mahmoud **Chaker** Bey (3), under secretary of State, General Manager of the Egyptian State Railways; Cairo;

Chiossi (3), vice-directeur général des chemins de fer de l'Etat italien; Rome;

C. **Colson** (already named);

R. **da Costa Couvreur** (1), ingénieur en chef de la division de la voie et des travaux de la Direction générale des chemins de fer, membre du Conseil supérieur des chemins de fer du Portugal; Rua A (Av. Largo Afonso Pena), No. L. V. G. 2-1er, Lisbon;

Dautry (3), directeur général des chemins de fer de l'Etat français; 20, rue de Rome, Paris;

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(1) Retires at the 13th session.
(2) Retires at the 14th session.
(3) Retires at the 15th session.
(*) Died in August, 1934.

Sir Francis **Dent** (3), C. V. O., director, Southern Railway (Great Britain); Dock House, Beaulieu (Hants), England;

B. **Djouritchitch** (2), ministre-adjoint des Communications du Royaume de Yougoslavie; Belgrad;

Dr. J. **Dorpmüller** (1), Generaldirektor der Deutschen Reichsbahn-Gesellschaft; 35, Voss-Strasse, Berlin W. 9;

F. **Fiori** (1), ingénieur, administrateur des chemins de fer de l'Etat italien; Villa Patrizi, Rome;

Sir Henry **Fowler** (2), K. B. E., chairman of Committee, Ministry of Transport, Great Britain; Spondon Hall, near Derby;

P. **Ghilain** (2), ingénieur en chef au service du matériel de la Société Nationale des chemins de fer belges; rue du Progrès, 74, Brussels;

A. **Granholm** (2), directeur général des chemins de fer de l'Etat suédois; Stockholm;

H. N. **Gresley** (2), chief mechanical engineer, London & North Eastern Railway; King's Cross Station, London, N. 1;

Ch. **Gufflet** (3), directeur de la Compagnie des Chemins de fer du Midi; 54, boulevard Haussmann, Paris;

Sir Hugh **Hannay** (3), agent, East Indian Railway; « Marlposts », Tarring (Sussex);

R. J. **Harvey** (3), consulting engineer to the Government of New-Zealand; 34, Victoria Street, Westminster, London, S. W. 1;

A. **Henry-Gréard** (3), directeur de la Compagnie du chemin de fer de Paris à Orléans; rue de Londres, 8, Paris;

H. **Hunziker** (1), ingénieur, directeur de la division des chemins de fer du Département fédéral des postes et des chemins de fer suisses; Berne;

Sir Cyril **Hurcomb** (1), K. B. E., C. B., secretary to the Ministry of Transport (Great-Britain); 6, Whitehall Gardens, London, S. W. 1;

L. **Jacobs** (1), directeur général de la Société Nationale belge des Chemins de fer Vicinaux; 14, rue de la Science, Brussels;

G. **Jadot** (1), directeur du service des finances de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Brussels;

H. **Jezierski** (1), conseiller ministériel au Ministère des Communications de Pologne; Warsaw;

Y. **Kawai** (2), manager of the Berlin Office of the Japanese Government Railways; Friedrich Ebert-Strasse, 6, Berlin W. 9;

E. **Kejr** (3), ingénieur, conseiller des constructions du département V/1 au Ministère des chemins de fer de Tchécoslovaquie; Prague;

H. E. Ibrahim Fahmy **Kerim** Pasha (already named);

Dr. Th. **Kittel** (2), Reichsbahndirektor, Mitglied der Hauptverwaltung der Deutschen Reichsbahngesellschaft; Voss-Strasse, 35, Berlin, W. 9;

P. **Knutzen** (3), directeur général des Chemins de fer de l'Etat danois; Sölvgade, 40, Copenhague, K.;

U. **Lamalle** (already named);

R. **Le Besnerais** (already named);

L. F. **Loree** (3), president, Delaware & Hudson Railroad; 32, Nassau Street, New York City;

A. **Mange** (1), administrateur de la Compagnie du chemin de fer de Paris à Orléans, président du Comité de gérance de l'Union internationale des chemins de fer; rue de la Bienfaisance, 42, Paris;

C. **Marchi** (1), député au Parlement italien, président général de la Confederazione Nazionale Fascista delle Imprese di Communicazioni Interne; via Quattro Fontane, 149, Rome;

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(1) Retires at the 13th session.
(2) Retires at the 14th session.
(3) Retires at the 15th session.

A. **Marguerat** (1), directeur des Compagnies de chemins de fer de Viège à Zermatt, Furka-Oberalp, Gornergrat et Schöllenen; Lausanne;

E. **Maristany** (3), marquis d'Argentera, directeur général de la Compagnie des chemins de fer de Madrid à Saragosse et à Alicante; Estación de Atocha, Madrid;

C. **Mereutza** (2), directeur général des Chemins de fer de l'Etat roumain; Bucharest;

L. **Moralès** (2), vice-président du Conseil supérieur des chemins de fer d'Espagne, président du Conseil d'administration des chemins de fer de l'Ouest de l'Espagne; Estación de las Delicias, Madrid;

J. **Moreno Ossorio** (1), Administrateur à la Commission permanente du Comité exécutif des Chemins de fer du Nord de l'Espagne; Estación del Norte, Madrid;

E. **Mugniot** (3), directeur général de la Compagnie des Chemins de fer de Paris à Lyon et à la Méditerranée; 88, rue St-Lazare, Paris (9e);

H. E. Mohamed **Osman** Bey (3), under secretary of State, Egyptian Ministry of Communications; Cairo;

G. **Philippe** (3), inspecteur général des lignes Nord belges; Liége;

C. **Ramallo** (2), ingénieur, director del Instituto de Economia de los Transportes, Facultad Nacional de Ciencias Económicas; Buenos Ayres;

Dr. W. **Rauscher** (2), conseiller ministériel, directeur commercial des Chemins de fer fédéraux autrichiens; Vienna;

P. **Riboud** (2), directeur de la Compagnie des chemins de fer de l'Est français; rue d'Alsace, 21, Paris;

The Right Hon. Lord **Rockley**, P. C., G. B. E. (already named);

N. **Rulot** (already named);

A. **Schrafl** (2), président de la Direction générale des chemins de fer fédéraux suisses; Berne;

Dr. Otto **Senn** (1), conseiller ministériel, président de la Direction des Chemins de fer royaux de l'Etat hongrois; Andràssy ut, 73, Budapest VI;

Sir Josiah **Stamp** (2), G. B. E., D. Sc., chairman and president of the Executive, London Midland & Scottish Railway; Euston Station, London N. W. 1;

T. C. **Swallow** (3), advisory engineer, Office of the High Commissioner for the Union of South Africa; South Africa House, Trafalgar Square, London W. C. 2;

R. E. **Thomas** (3), deputy general manager, Egyptian State Railways; Cairo;

Antonio **Valenciano y Mazerès** (2), inspecteur général des ponts et chaussées, administrateur de la Compagnie des chemins de fer de Madrid à Saragosse et à Alicante; General Oráa, 5-3o, Madrid;

H. **van Manen** (1), directeur des chemins de fer néerlandais; Utrecht;

Th. M. B. **van Marle** (3), inspecteur général des chemins de fer et tramways néerlandais; Koningskade, 25, The Hague;

L. **Velani** (1), directeur général des chemins de fer de l'Etat italien; Villa Patrizi, Rome;

A. M. M. **Verkoyen**, directeur du service du matériel de la Société nationale des Chemins de fer belges; 17, rue de Louvain, Brussels;

D. **Vickers** (already named);

Dr. C. C. **Wang** (2), representative of the Chinese Ministry of Railways; 21, Tothill Street, Westminster, London, S. W. 1;

Sir Ralph Lewis **Wedgwood** (1), C. B., C. M. G. chief general manager, London & North Eastern Railway; King's Cross Station, London, N. 1;

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(1) Retires at the 13th session.
(2) Retires at the 14th session.
(3) Retires at the 15th session.

D. **Willard** (1), chairman of the Board, American Railway Association; president, Baltimore & Ohio Railroad; Baltimore, Md.;

P. **Wolf** (3), Geheimrat, Direktor der Deutschen Reichsbahn-Gesellschaft und Mitglied des Direktionsausschusses dieser Gesellschaft; Voss-Strasse, 35, Berlin, W. 9;

N... (1) (Australia);

N... (1) (Belgium);

N... (1) (Brazil);

N... (2) (Germany);

N... (3) (Germany).

Honorary member : Gustav **Behrens,** director, London Midland & Scottish Railway; 20, Chepstow Street, Manchester.

SECRETARY'S OFFICE : rue du Progrès, 74, Brussels.

General secretary : P. **Ghilain** (already named).

Assistant secretaries : A. W. **Chantrell,** ingénieur principal à la Société Nationale des Chemins de fer belges;

E. **Minsart,** ingénieur principal à la Société Nationale des Chemins de fer belges;

R. **Desprets,** ingénieur principal à la Société Nationale des Chemins de fer belges.

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(1) Retires at the 13th session.
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